PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 : C12N 15/86, 7/04, A61K 39/245, C12N 15/38 — A2

(11) International Publication Number: WO 94/21807

(43) International Publication Date: 29 September 1994 (29.09.94)

(21) International Application Number: PCT/GB94/00572

(22) International Filing Date: 21 March 1994 (21.03.94)

(30) Priority Data:

9305710.7	19 March 1993 (19.03.93)	GB
9324964.7	6 December 1993 (06.12.93)	GB

(71) Applicant *(for all designated States except US)*: CANTAB PHARMACEUTICALS RESEARCH LIMITED [GB/GB]; 184 Cambridge Science Park, Milton Road, Cambridge CB4 4GN (GB).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: INGLIS, Stephen, Charles [GB/GB]; 2 Rhugarve Gardens, Linton, Cambridge CB1 6LX (GB). BOURSNELL, Michael, Edward, Griffith [GB/GB]; 46 Netherhall Way, Cambridge CB1 4NY (GB). MINSON, Anthony, Charles [GB/GB]; 113 Cambridge Road, Great Shelford, Cambridge CB2 5JJ (GB).

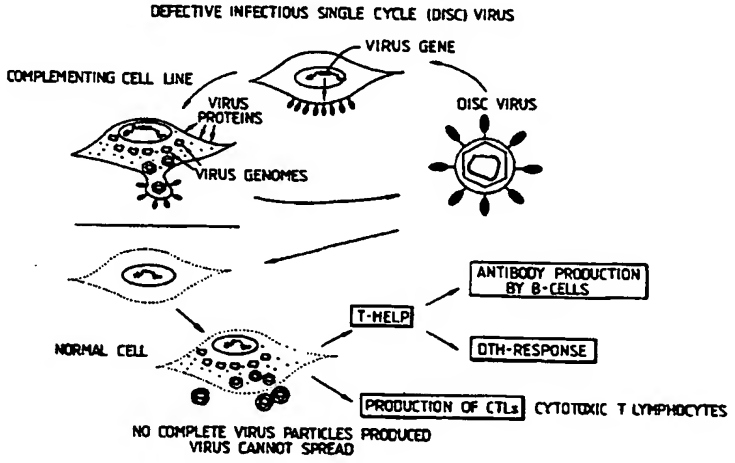
(74) Agent: O'BRIEN, Caroline; Mewburn Ellis, York House, 23 Kingsway, London WC2B 6HP (GB).

(81) Designated States: AT, AU, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, ES, FI, GB, HU, JP, KP, KR, KZ, LK, LU, LV, MG, MN, MW, NL, NO, NZ, PL, PT, RO, RU, SD, SE, SI, SK, UA, US, UZ, VN, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published

Without international search report and to be republished upon receipt of that report.

(54) Title: DEFECTIVE MUTANT NON-RETROVIRAL VIRUS (E.G. HSV) AS VACCINE



(57) Abstract

The application provides a pharmaceutical which comprises a mutant non-retroviral virus (particularly HSV-1 and/or HSV-2) whose genome is defective in respect of a gene essential for the production of infectious virus. The virus can infect normal cells and undergo replication and expression of viral antigen genes in those cells but cannot produce normal infectious virus. The pharmaceutical is for prophylactic or therapeutic use in generating an immune response in a subject infected therewith. Where the non-retroviral virus is a herpes simplex virus e.g. HSV-1 or HSV-2, the defect can be in the glycoprotein gH gene. Vaccines and therapeutic pharmaceuticals are provided especially for epithelial, oral, vaginal and nasal administration. Also provided is use of a mutant based on HSV-1 for the preparation of a pharmaceutical for prophylactic or therapeutic use in generating an immune response in a subject against type-2 HSV infection.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	GB	United Kingdom	MR	Mauritania
AU	Australia	GE	Georgia	MW	Malawi
BB	Barbados	GN	Guinea	NE	Niger
BE	Belgium	GR	Greece	NL	Netherlands
BF	Burkina Faso	HU	Hungary	NO	Norway
BG	Bulgaria	IE	Ireland	NZ	New Zealand
BJ	Benin	IT	Italy	PL	Poland
BR	Brazil	JP	Japan	PT	Portugal
BY	Belarus	KE	Kenya	RO	Romania
CA	Canada	KG	Kyrgystan	RU	Russian Federation
CF	Central African Republic	KP	Democratic People's Republic of Korea	SD	Sudan
CG	Congo			SE	Sweden
CH	Switzerland	KR	Republic of Korea	SI	Slovenia
CI	Côte d'Ivoire	KZ	Kazakhstan	SK	Slovakia
CM	Cameroon	LI	Liechtenstein	SN	Senegal
CN	China	LK	Sri Lanka	TD	Chad
CS	Czechoslovakia	LU	Luxembourg	TG	Togo
CZ	Czech Republic	LV	Latvia	TJ	Tajikistan
DE	Germany	MC	Monaco	TT	Trinidad and Tobago
DK	Denmark	MD	Republic of Moldova	UA	Ukraine
ES	Spain	MG	Madagascar	US	United States of America
FI	Finland	ML	Mali	UZ	Uzbekistan
FR	France	MN	Mongolia	VN	Viet Nam
GA	Gabon				

DEFECTIVE MUTANT NON-RETROVIRAL VIRUS (E.G. HSV) AS VACCINE.

The present invention relates to viral vaccines.

Viral vaccines are traditionally of two sorts. The first sort are 'killed' vaccines, which are virus preparations which have been killed by treatment with a suitable chemical such as beta-propriolactone. The second type are live 'attenuated' vaccines, which are viruses which have been rendered less pathogenic to the host, either by specific genetic manipulation of the virus genome, or, more usually, by passage in some type of tissue culture system. These two types of vaccine each have their own disadvantages. Since killed vaccines do not replicate in the host, they are usually administered by injection, and hence may generate an inappropriate kind of immune response. For example the Salk vaccine, a killed preparation of poliovirus, produces an imunoglobulin (Ig) G antibody response, but does not stimulate the production of IgA in the gut, the natural site of primary infection. Hence this vaccine, though it can protect the individual from the neurological complications of poliomyelitis, does not block primary infection, and so does not confer "herd immunity". In addition, killed viruses, do not enter and replicate inside host cells. Hence any beneficial immunological response to non-structural proteins produced during replication is not available. They also often fail to stimulate the production of cytotoxic T cells directed against virus antigens. "Dead" antigens can be picked up by antigen presenting cells and presented to T cells. However, the presentation occurs via MHC Class II molecules

and leads to stimulation of T helper cells. In turn, the T helper cells help B cells to produce specific antibody against the antigen. In order to stimulate the production of cytotoxic T cells, virus antigens must be processed through a particular pathway inside the infected cell, and presented as broken-up peptide fragments on MHC Class I molecules. This degradation pathway is thought to work most effectively for proteins that are synthesised inside the infected cell, and hence only virus that enters host cells and expresses immunogenic viral protein is capable of generating virus-specific cytotoxic T cells. Therefore, killed vaccines are poor inducers of cytotoxic T cells against virus infection. From this point of view, live attenuated vaccines are more satisfactory.

To date, live attenuated viruses have been made by deleting an inessential gene or partly damaging one or more essential genes (in which case, the damage is such that the genes are still functional, but do not operate so effectively). However, live attenuated viruses often retain residual pathogenicity which can have a deleterious effect on the host. In addition, unless the attenuation is caused by a specific deletion, there remains the possibility of reversion to a more virulent form. Nevertheless, the fact that some viral protein production occurs in the host means that they are often more effective than killed vaccines which cannot produce such viral protein.

Live attenuated viruses, as well as being used as vaccines in their own right, can also be used as 'vaccine

vectors' for other genes, in other words carriers of genes from a second virus (or other pathogen) against which protection is required. Typically, members of the pox virus family eg. vaccinia virus, are used as vaccine vectors. When a virus, is used as a vaccine vector, it is important that it causes no pathogenic effects. In other words it may need to be attenuated in the same way that a simple virus vaccine is attenuated. The same disadvantages as those described above, therefore apply in this case.

It has been found possible to delete an essential gene from a viral genome whilst also providing a so-called 'complementing' cell which provides the virus with the product of the deleted gene. This has been achieved for certain viruses, for example adenoviruses, herpesviruses and retroviruses. For adenoviruses, a human cell line was transformed with fragments of adenovirus type 5 DNA (Graham, Smiley, Russell & Nairn, J. Gen. Virol., 36, 59-72, 1977). The cell line expressed certain viral genes, and it was found that it could support the growth of virus mutants which had those genes deleted or inactivated (Harrison, Graham & Williams, Virology 77, 319-329, 1977). Although the virus grew well on this cell line (the 'complementing cell line') and produced standard viral particles, it could not grow at all on normal human cells. Cells expressing the T-antigen-encoding region of the SV40 virus genome (a papovavirus) have also been shown capable of supporting the replication of viruses specifically deleted in this region (Gluzman, Cell, 23, 182-195, 1981).

For herpes simplex virus, cell lines expressing the gB glycoprotein (Cai et al, J. Virol. 62, 714-721, 1987) the gD glycoprotein (Ligas and Johnson, J. Virol. 62, 1486, 1988) and the Immediate Early protein ICP4 (Deluca et al., J. Virol., 56, 558, 1985) have been produced, and these have been shown capable of supporting the replication of viruses with specifically inactivated copies of the corresponding genes.

WO92/05263 published on 2 April 1992 provides a mutant non-retroviral virus whose genome is defective in respect of a gene essential for the production of infectious virus, such that the virus can infect normal cells and undergo replication and expression of viral antigen genes in those cells but cannot produce normal infectious virus.

Mutant non-retroviral viruses in accordance with the teaching of WO92/05263 provide a unique way of combining the efficacy and safety of a killed vaccine with the extra immunological response induced by the in vivo production of viral protein by the attenuated vaccine. In preferred embodiments, the invention of WO92/05263 comprises two features. Firstly, a selected gene is inactivated within the virus genome, usually by creating a specific deletion. This gene will be involved in the production of infectious virus, but preferably not preventing replication of the viral genome. Thus the infected cell can produce more viral protein from the replicated genetic material, and in some cases new virus particles may be produced, but these would not be infectious. This means that the viral

infection cannot spread from the site of inoculation.

A second feature of the invention of WO92/05263 is a cell which provides the virus with the product of the deleted gene, thus making it possible to grow the virus in tissue culture. Hence, although the virus lacks a gene encoding an essential protein, if it is grown in the appropriate host cell, it will multiply and produce complete virus particles which are to outward appearances indistinguishable from the original virus. This mutant virus preparation is inactive in the sense that it has a defective genome and cannot produce infectious virus in a normal host, and so may be administered safely in the quantity required to generate directly a humoral response in the host. Thus, the mutant virus need not be infectious for the cells of the host to be protected and merely operates in much the same way as a conventional killed or attenuated virus vaccine. However, preferably the immunising virus is itself still infectious, in the sense that it can bind to a cell, enter it, and initiate the viral replication cycle and is therefore capable of initiating an infection within a host cell of the species to be protected, and producing therein some virus antigen. There is thus the additional opportunity to stimulate the cellular arm of the host immune system.

In particular, it is to be mentioned that WO92/05263 provided in vivo data which showed that intra-epithelial vaccination of mice via the ear with a mutant form (as described above) of HSV-1 gave better protection against

later challenge with wild-type HSV-1, than similar vaccination with killed HSV-1. A clear protective effect against the establishment of latent infection in the cervical ganglia was also shown for vaccination with the mutant HSV-1.

The applicants call the above described mutant viruses DISC viruses (standing for 'defective infectious single cycle) and the basic concept is illustrated in Fig. 1. The present application goes on from the work disclosed in WO92/05263.

The present application makes the disclosures summarised below.

(1) In a study using the mouse ear model the results reported in WO92/05263 were confirmed. Intra-epithelial vaccination of mice with DISC HSV-1 led to complete protection against replication of the challenge virus wild type (w.t.) HSV-1. Little effective protection was provided by equivalent doses of inactivated HSV-1. DISC HSV-1 also protected against the establishment of latent infection in the cervical ganglia.

(2) Also in the mouse ear model it is shown that no significant differences in antibody titres were observed between animals vaccinated with DISC HSV-1 and an equivalent amount of inactivated HSV-1.

(3) Also in the mouse ear model it is shown that at low vaccination doses, inactivated HSV-1 failed to established a delayed-type hypersensitivity (DTH) response, whilst equivalent doses of DISC HSV-1 established a DTH

response. At high doses, both DISC HSV-1 and inactivated HSV-1 induced similar DTH responses.

(4) Also in a mouse study it was shown that in contrast to vaccination with inactivated HSV-1, vaccination with DISC HSV-1 induced HSV-1 specific cytotoxic T cell activity.

(5) The in vivo mouse ear model was used to study long term prophylactic effect of DISC HSV-1. Two vaccinations of DISC HSV-1 was found to provide better long term protection against challenge with w.t. HSV-1 than two vaccinations of inactivated DISC HSV-1

(6) The in vivo mouse ear model was used to investigate the prophylactic effect of DISC HSV-2 against HSV-2 infection. Intra-epithelial vaccination of mice with DISC HSV-2 provided better protection against replication of the challenge virus w.t. HSV-2 than inactivated DISC HSV-2.

(7) The in vivo guinea-pig vaginal model was used to study the prophylactic effect of DISC HSV-1 against HSV-2 infection. It was shown that intra-epithelial or intra-vaginal vaccination with DISC HSV-1 provided a high degree of protection against the primary symptoms of HSV-2 infection. Immunisation with DISC HSV-1 or inactivated virus retarded growth of challenge virus w.t. HSV-2 in the vagina. Further intra-vaginal vaccination with DISC HSV-1 lessened the number of recurrent HSV-2 lesions in a 100 day follow-up period. Intra-epithelial vaccination with DISC HSV-1 and inactivated virus also resulted in reduced

recurrent lesions, but compared to intra-vaginal vaccination with DISC HSV-1, the reduction was less.

(8) Oral and intranasal vaccination of guinea-pigs with DISC HSV-1 led to protection against acute disease symptoms following challenge with w.t. HSV-2. The intranasal route appeared to be more effective than the oral route.

The per vaginum vaccination route in comparison to oral or intra-nasal vaccination resulted in significantly lower levels of recovered virus following challenge.

(9) In guinea-pigs which had recovered fully from primary HSV-2 disease, the therapeutic administration of DISC HSV-1 either intra-vaginally or intra-epithelially resulted in an apparent reduction in the frequency of recurrent of disease symptoms compared with mock vaccinated animals.

(10) In guinea-pigs which had recovered fully from primary HSV-2 disease, intra-vaginal therapeutic administration of DISC HSV-2 was more effective in reducing the frequency of recurrence of disease symptoms than treatment with DISC HSV-1.

The present invention provides a pharmaceutical mutant which comprises a mutant non-retroviral virus whose genome is defective in respect of a gene essential for the production of infectious virus such that the virus can infect normal cells and undergo replication and expression of viral antigen genes in those cells but cannot produce normal infectious virus, for prophylactic or therapeutic

use in generating an immune response in a subject infected therewith.

The defect may allow the production and release from the cells of non-infectious viral particles.

The present invention provides a pharmaceutical which comprises a mutant non-retroviral virus whose genome is defective in respect of a gene essential for the production of infectious virus such that the virus can infect normal cells and replicate therein to give rise to the production and release from the cells of non-infectious viral particles. The pharmaceutical may be a vaccine capable of protecting a patient immunised therewith against infection or the consequences of infection by a non-retroviral virus. The pharmaceutical may be a vaccine capable of protecting a patient immunised therewith against infection or the consequences of infection by the corresponding wild-type virus.

The pharmaceutical may be a therapeutic capable of treating a patient with an established non-retroviral virus infection. The pharmaceutical may be a therapeutic capable of treating a patient with an infection established by the corresponding wild-type virus.

The pharmaceutical may be sub-cutaneously, intra-muscularly, intra-dermally, epithelially-, (with or without scarification), nasally-, vaginally-, or orally-administrable comprising excipients suitable for the selected administration route.

The mutant may be from a double-stranded DNA virus.

The mutant may be from a herpes virus. The mutant may be from a herpes simplex virus (HSV).

The mutant may be a type-1 HSV or a type-2 HSV. The defect may be in the glycoprotein gH gene.

The present invention provides a type-2 HSV whose genome is defective in respect of a gene essential for the production of infectious HSV-2 such that the virus can infect normal cells and undergo replication and expression of viral antigens in those cells but cannot produce normal infectious virus, for prophylactic or therapeutic use in generating an immune response in a subject infected with HSV eg HSV-2.

The mutant HSV-2 defect allows the production and release from the cells of non-infectious virus particles.

Also provided is a type-2 HSV whose genome is defective in respect of a gene essential for the production of infectious HSV-2 such that the virus can infect normal cells and replicate therein to give rise to the production and release from the cells of non-infectious viral particles.

The mutant may be capable of protecting a patient immunised therewith against infection or the consequences of infection with HSV eg infection by the corresponding wild-type virus.

The mutant may be capable of treating a patient with an established HSV infection eg infection by the corresponding wild-type virus.

The defect may be in the glycoprotein gH gene.

The present invention also provides use of a mutant type-1 HSV whose genome is defective in respect of a gene essential for the production of HSV-1 such that the virus can infect normal cells and undergo replication and expression of viral antigen genes in those cells but cannot produce normal infectious virus, for preparation of a pharmaceutical for prophylactic or therapeutic use in generating an immune response in a subject against type-2 HSV infection.

The use may be in respect of pharmaceuticals for intra-epithelial (with or without scarification), intra-vaginal, intra-nasal or per-oral administration.

The present invention also provides an assembly comprising a pharmaceutical (for prophylaxis ie a vaccine or for therapy ie a therapeutic) as described above in a container preferably a pre-filled syringe or glass vial/ampoule with printed instructions on or accompanying the container concerning the administration of the pharmaceutical to a patient to prevent or treat conditions caused by HSV infection. The printed instructions may concern the prevention or treatment of facial or genital lesions.

Vaccines containing the mutants as described can be prepared in accordance with methods well known in the art wherein the mutant is combined in admixture with a suitable vehicle. Suitable vehicles include, for example, saline solutions, or other additives recognised in the art for use in compositions applied to prevent viral infections. Such

vaccines will contain an effective amount of the mutant as hereby provided and a suitable amount of vehicle in order to prepare a vaccine useful for effective administration to the host.

Dosage rates can be determined according to known methods. For example, dosage rate may be determined by measuring the optimum amount of antibodies directed against a mutant resulting from administration of varying amounts of the mutant in vaccine preparations. Attention is directed to New Trends and Developments in Vaccines, Editors: A. Voller and H. Friedman, University Park Press, Baltimore, 1978 for further background details on vaccine preparation.

Therapeutics comprising a mutant as herein provided can be formulated according to known methods to provide therapeutically useful compositions, whereby the mutant is combined in admixture with a pharmaceutically acceptable carrier vehicle. Suitable vehicles and their formulation are described in Remington's Pharmaceutical Science by E. W. Martin. Such compositions will contain an effective amount of the mutant hereof together with a suitable amount of carrier vehicle in order to prepare therapeutically acceptable compositions suitable for effective administration to the host.

Typically vaccines are prepared as injectables, (traumatic or non-traumatic) either as liquid solutions or suspensions; solid forms suitable for solution in, or suspension in, liquid prior to injection may also be

prepared. Preparations may also be encapsulated in liposomes. The active immunogenic ingredients are often mixed with excipients which are pharmaceutically acceptable and compatible with the active ingredient. Suitable excipients are, for example, water, saline, dextrose, glycerol, trehalose, or the like and combinations thereof. In addition, if desired, the vaccine may contain minor amounts of auxiliary substances such as other stabilisers and/or pH buffering agents, which enhance the stability and thus the effectiveness of the vaccine.

The vaccines may be administered parenterally, by injection, for example, subcutaneously, intraepithelially (with or without scarification). Additional formulations which are suitable for other modes of administration eg oral, vaginal and nasal formulations are also provided. Oral formulations include such normally employed excipients as, for example, pharmaceutical grades of trehalose mannitol, lactose, starch, magnesium stearate, sodium saccharine, cellulose, magnesium carbonate, and the like. The compositions may take the form of solutions, suspensions, tablets, pills, capsules sustained release formulations or powders.

The vaccines are administered in a manner compatible with the dosage formulation, and in such amount as will be prophylactically effective. The quantity to be administered will have been predetermined from preclinical and clinical (phase I) studies to provide the optimum immunological response.

The vaccine may be given in a single dose schedule, or preferably in a multiple dose schedule. A multiple dose schedule is one in which a primary course of vaccination may be with 1-3 separate doses, followed by other doses given at subsequent time intervals required to maintain and or re-enforce the immune response, for example, at 1-4 months for a second dose, and if needed, a subsequent dose(s) after several months. The dosage regimen will also, have been determined from preclinical and clinical studies as maintaining the optimum immunological response over time.

In order that the invention is more clearly understood, it will be further described by way of example only, and not by way of limitation, with reference to the following figures.

Figure 1 illustrates the DISC virus concept.

Figure 2 shows clearance of wild-type HSV-1 (w.t. HSV-1) strain SC16 virus in the ears of mice vaccinated with either live DISC HSV-1 or inactivated (β-propiolactone treated) w.t. HSV-1 (strain SC16). Groups of 4 mice were vaccinated at the doses indicated by scarification of the left ear pinna. Mice were challenged 14 days post-vaccination with $2x10^{6}$ pfu w.t. HSV-1 strain SC16 in the right ear pinna and virus titres were measured 5 days post challenge. Data are expressed as the geometric means and standard errors of the means.

Figure 3 shows measurement of titres of neutralising and ELISA antibody to w.t. HSV-1 in mice vaccinated with

either w.t. HSV-1 (strain SC16), live DISC HSV-1, killed DISC HSV-1 or PBS. Sera from mice were assayed in the presence of complement for neutralising antibodies to w.t. HSV-1 in a plaque reduction assay. Individual titres are expressed as the reciprocal dilution of sera required to neutralise 50% of the infectivity obtained in the absence of antibody.

Figure 4 shows delayed-type hypersensitivity (DTH) responses in mice vaccinated with either w.t. HSV-1 (strain SC16), live DISC HSV-1, killed DISC HSV-1 or PBS. Mice were vaccinated in the left ear pinna at the doses indicated 14 days prior to challenge with 10^6 pfu w.t. HSV-1 (strain SC16) in the opposite ear. Ear thickness was measured 24 and 48 hours post-challenge and is expressed as the difference between the challenged and vaccinated ear. Data are presented as the means of differences in ear thickness (in μm).

Figure 5 shows cytotoxic T cell (CTL) responses in mice vaccinated with either live DISC HSV-1, killed DISC HSV-1, MDK (a thymidine kinase negative HSV-1 strain) or PBS. Mice were immunised twice intraperitoneally three weeks apart and cell suspensions made from spleens 10 days after the second injection. Cells were stimulated in vitro for 4 days before being tested in a CTL assay using ^{51}Cr-labelled A20/2J as target cells. Data are presented as mean % ^{51}Cr release from quadruplicate samples at each point. Standard errors of the means are all <10%.

Figure 6 shows clinical symptoms as assessed by

erythema score in guinea-pigs post challenge with $10^{5.2}$ pfu w.t. HSV-2 (strain MS) subsequent to vaccination with doses of 2 x 10^7 pfu DISC HSV-1 at a 3 week interval either by the intra-epithelial or the intra-vaginal route;

Figure 7 shows clinical symptoms as assessed by total lesion score in guinea-pigs post challenge with $10^{5.2}$ pfu w.t. HSV-2 (strain MS) subsequent to vaccination with doses of 2 x 10^7 pfu DISC HSV-1 at a 3 week interval either by the intra-epithelial or the intra-vaginal route.

Figure 8 shows post challenge virus w.t. HSV-2 (strain MS) replication in guinea-pigs post challenge with $10^{5.2}$ pfu w.t. HSV-2 (strain MS) subsequent to vaccination with doses of 2 x 10^7 pfu DISC HSV-1 at a 3 week interval either by the intra-epithelial or the intra-vaginal route.

Figures 9a and 9b show recurrent disease in guinea-pigs post challenge with $10^{5.2}$ pfu w.t. HSV-2 (strain MS) subsequent to vaccination with doses of 2 x 10^7 pfu DISC HSV-1 at a 3 week interval by the intra-epithelial or the intra-vaginal route. Fig. 9a shows recurrent disease as the cumulative mean erythema index per animal. Fig. 9b shows recurrent disease as cumulative mean number of days with disease per animal.

Figure 10 shows mean lesion score per animal (guinea-pigs) with w.t. HSV-2 (strain MS) infection and which have been vaccinated via the vaginal, oral or nasal routes with a mock virus preparation, DISC HSV-1 or inactivated DISC HSV-1.

Figure 11 shows mean erythema score per animal

(guinea-pigs) with w.t. HSV-2 (strain MS) infection and which have been vaccinated via the vaginal, oral or nasal routes with a mock virus preparation, DISC HSV-1 or inactivated DISC HSV-1.

Figure 12 shows the mean log titre of w.t. HSV-2 (strain MS) per animal (guinea-pigs) with w.t. HSV-2 (strain MS) infection and which have been vaccinated via the vaginal, oral or nasal routes with a mock virus preparation, DISC HSV-1 or inactivated DISC HSV-1.

Figure 13 shows recurrent disease following therapeutic vaccination. This is shown as mean cumulative number of days on which disease was observed (disease/days) in groups of guinea-pigs vaccinated with DISC HSV-1 either intra-epithelially or intra-vaginally or with a mock virus preparation intra-vaginally after challenge with w.t. HSV-2 (strain MS). Disease was classified as either presence of one or more lesions or an erythema score of 1 or more. Animals were monitored from 4 weeks after initial challenge with w.t. HSV-2 (strain MS) (day o) for 100 days. Animals were vaccinated at Day 0, Day 24 and Day 44 with 2×10^7 pfu or equivalent dose as indicated.

Figure 14 relates to the long-term protective effect in mice of vaccination with DISC HSV-1 against challenge with w.t. HSV-1 (strain SC16). The graph shows the mean log titre of w.t. HSV-1 in the ears 5 days post challenge and 223 days post vaccination.

Figure 15 relates to the long-term protective effect in mice of vaccination with DISC HSV-1 against challenge

with w.t. HSV-1 (strain SC16). The graph shows neutralising antibody titres days 15, 27, 90, 152 and 218 post vaccination as stated.

Figure 16 relates to the protective effect in mice of vaccination with DISC HSV-2 against challenge with w.t. HSV-2 (strain HG52) for vaccinations with live DISC HSV-2, killed DISC HSV-2 and w.t. HSV-2 (strain HG52) at varying doses, the graph shows mean log titre of w.t. HSV-2 in the ear post challenge.

Figure 17 illustrates the construction of a single plasmid containing the complete HSV-2 gH gene.

Figure 18 shows the sequence of HSV-2 strain 25766 in the region of the gH gene including a translation of the gH gene in single letter amino acid code.

Figure 19 shows a comparison of the DNA sequence of HSV-1 and HSV-2 strain 25766 in the region of the gH gene.

Figure 20 shows a comparison of the deduced amino acid sequences of the HSV-1 strain 17 and HSV-2 strain 25766 gH proteins.

Figure 21 shows graphically the level of similarity between the DNA sequences of HSV-1 and HSV-2 in the region of the gH gene (from UWGCG program Plotsimilarity).

Figure 22 shows graphically the level of similarity between the amino acid sequences of the HSV-1 and HSV-2 gH proteins (from UWGCG program Plotsimilarity).

Figure 23 shows the construction of pIMMB26; two fragments from the left and right sides of the HSV2 gH gene were amplified by PCR and cloned into pUC119. The four

oligonucleotides MB57, MB58, MB59 and MB60 are shown.

Figure 24 shows the construction of pIMMB45.

Figure 25 shows construction of the first stage recombination vector pIMMB47+.

Figure 26 shows construction of the second stage recombination vector pIMMB46.

Figure 27 shows a restriction map analysis for recombinants HG52-D, TK minus DISC virus, TK plus DISC virus.

Figure 28 shows Southern blots of BamHI digestions of various viruses, probed with the right-hand flanking sequence as shown in Fig. 27. Lane 5: HG52-D virus, lane 2: TK-minus "first stage" DISC virus and lanes 3, 4, 6, 7 and 8: TK-plus "second stage" DISC viruses.

Herpes Simplex Virus Deleted in Glycoprotein H (gH-HSV)

Herpes simplex virus (HSV) is a large DNA virus which causes a wide range of pathogenic symptoms in man, including recurrent facial and genital lesions, and a rare though often fatal encephalitis. In general, it seems that type 1 HSV (HSV-1) seems to be particularly associated with facial lesions, whilst type 2 HSV (HSV-2) seems to be particularly associated with genital lesions. To some extent infection with HSV can be controlled by chemotherapy using the drug Acyclovir, but as yet there is no vaccine available to prevent primary infection or the consequences of this infection. Thus there is a need both for better therapeutics to treat established HSV infections and for

prophylactics to prevent the establishment of HSV infection and/or its associated pathology.

A difficulty with vaccination against HSV is that the virus generally spreads within the body by direct transfer from cell to cell. Thus humoral immunity is unlikely to be effective, since circulating antibody can only neutralise extracellular virus. Of more importance for the control of virus infection, is cellular immunity, and so a vaccine which is capable of generating both humoral and cellular immunity, but which is also safe, would be a considerable advantage.

A suitable target gene for inactivation within the HSV genome is the glycoprotein H gene (gH). The gH protein is a glycoprotein which is present on the surface of the virus envelope. This protein is thought to be involved in the process of membrane fusion during entry of the virus into the infected cell. This is because temperature sensitive virus mutants with a lesion in this gene are not excreted from virus infected cells at the non-permissive temperature (Desai et al., J. Gen. Virol. 69, 1147-1156, 1988). The protein is expressed late in infection, and so in its absence, a considerable amount of virus protein synthesis may still occur.

All genetic manipulation procedures are carried out according to standard methods described in "Molecular Cloning", A Laboratory Manual, eds. Sambrook, Fritsch and Maniatis, Cold Spring Harbor Laboratory Press, 1989.

METHODOLOGY

PREPARATION OF A DISC HSV-1

A. Generation of a Cell Line Expressing the HSV-1 gH gene

This was carried out in accordance with the teaching of WO92/05263 published on 2 April 1992 and incorporated herein by reference and also using standard procedures in the art.

B. Production of a DISC HSV Type 1 Virus Having an Interrupted gH Gene

This was carried out in accordance with the teaching of WO92/05263 published on 2 April 1992 and incorporated herein by reference and also using standard procedures in the art.

C. Relevant Publications

(i) Forrester A. et al J. Virol. 1992; 66 p341-348

(ii) Farrell H., et al. J. Virol. 1994; 68 p927-932

PREPARATION OF A DISC HSV-2

A. The HSV2 gH Gene

(a) The Herpes Simplex type 2 (HSV2) gH gene is contained within two BamH1 restriction fragments of the 25766 strain of HSV2. pTW49 is the BamH1 R fragment of HSV2 strain 25766 cloned into pBR322. pTW54 is the BamH1 S Fragment of HSV2 strain 25766 cloned into pBR322. The construction of a single plasmid containing the complete gH

gene is shown in Figure 17. pTW49 was digested with BamH1 and Sal1, and an 870 base pair (bp) fragment isolated from an agarose gel. Similarly pTW54 was digested with BamH1 and Kpn1 and a 2620bp fragment isolated from an agarose gel. The two fragments were ligated together with the plasmid pUC119 cut with Sal1 and Kpn1, resulting in the plasmid pIMMB24.

(b) pIMMB24 was digested with Sal1 and Kpn1. In addition the plasmid was digested with Dra1 (which cuts in the vector sequences), to aid in isolation of the 3490bp insert. The 3490bp insert containing the HSV2 sequences was purified from an agarose gel. It was then sonicated, the ends repaired using T4 DNA polymerase and Klenow, and size fractionated on an agarose gel. A fraction containing DNA molecules of approximately 300-600bp in length was ligated into M13mp11 cut with Sma1 (Amersham International UK). The ligated mixture was transformed into E.coli strain TG1, and individual plaques were picked. Single-stranded DNA was made from each plaque picked, and was sequenced using the dideoxy method of sequencing, either with Klenow enzyme or with Sequenase, and using ^{35}S dATP.

In addition to sequencing in M13 using an oligonucleotide priming from within the M13 sequences, sequence data was also obtained by sequencing directly from the pIMMB24 plasmid using oligonucleotide primers designed from sequence already obtained. In order to obtain sequence from regions flanking the gH gene, some sequence information was also obtained from the plasmid pTW49.

Because of the high G+C ratio of HSV2 DNA, there were several sequence interpretation problems due to 'compressions' on the gels. These have yet to be resolved. In a small number of places therefore, the present sequence represents the best guess as to what the correct sequence is, based on comparisons with the previously published HSV1 sequence.

(c) The sequence of HSV2 strain 25766 in the region of the gH gene is shown in Figure 18, along with a translation of the gH in single letter amino acid code. Figure 19 shows a comparison of the DNA sequence of HSV1 and HSV2 in this region. Figure 20 shows a comparison of the deduced amino acid sequences of the HSV1 and HSV2 gH proteins. At the DNA level the overall identity is 77%. At the protein level the overall identity is also 77%, with a further 9.7% of amino acids being similar in properties. The degree of sequence similarity varies to some extent along the length of the gene, as can be seen from Figure 21, which shows graphically the level of similarity. Even more marked than the variation along the gH gene is the difference in levels of identity between HSV1 and HSV2 at the DNA level between the coding and non-coding regions. As can be seen from Figure 19, the nucleotide sequence identity is higher within the coding sequence of the gH gene than it is in the intergenic regions. Figure 21 shows this in a graphical form, with the positions of the TK, gH and UL21 genes marked.

(d) The availability of nucleotide sequence data from

around the HSV-2 gH gene enables further constructs to be made eg it allows the design of recombination vectors which enables precise deletion of the gene from the viral genome. Because of the differences between HSV1 and HSV2, particularly between the genes, may not have been possible from knowledge of the HSV1 sequence alone.

Oligonucleotides MB57, MB58, MB59 and MB75 were designed to isolate and clone the regions of sequence flanking the HSV2 gH gene. As shown in Figure 23, the oligonucleotides were used in a polymerase chain reaction (PCR) to amplify fragments of DNA from either side of the gene. Restriction sites were included in the oligonucleotides so that the resultant fragments contained these sites at their ends, enabled cloning of the fragments into a suitably cut plasmid. The following oligonucleotides, based on the HSV2 sequence, were used for this purpose:

			HpaI
Inside right	MB57	TCAGTTAACGCCTCTGTTCCTTTCCCTTC	
			EcoR1
Outside right	MB58	TCAGAATTCGAGCAGCTCCTCATGTTCGAC	
			HpaI
Inside left	MB75	TCAGTTAACCGTCGTCCCGGCTGCCAGTC	
			HindIII
Outside left	MB59	TCAAAGCTTCTGCAGCGCGGCGGGAGGTGG	

The position of these oligonucleotides is also shown on Figure 19.

In accordance with the teachings made in PCT/GB91/01632 (WO 92/05263) and common general knowledge,

such a plasmid allows the skilled person to produce a defective HSV-2 virus lacking precisely the sequences for the gH gene (see below). If these same sequences are cloned into a suitable cell carrying a copy of the gH gene deleted from the HSV-2 genome, this 'complementing cell' can then support the growth of the defective HSV-2 virus by providing the gH protein. Because the sequences have been chosen so that there is no overlap between the sequences in the cell and the sequences in the virus, the possibility of the virus acquiring the gene from the cell by recombination is virtually eliminated.

B Construction of a gH Defective Type 2 Herpes Simplex Virus (DISC HSV-2)

Complementing Cell Lines

It was found that cells expressing the HSV-1 gH gene (F6 cells, Forrester et al, Journal of Virology, 1992, 66, p. 341-348) can support the growth of an HSV-2 virus lacking the gH gene. However two new cell lines were made. CR1 cells use the same promoter and gH gene as F6 cells, but the sequences downstream of the gene are truncated so that there is no overlap of sequences between the final DISC virus and the cell line. This is very useful since it means that homologous recombination cannot occur between the DISC virus and the cell line DNA. In the case of F6 cells and the gH-deleted virus in the Forrester paper, where there is overlap, wild-type gH-plus viruses occur by recombination at about 1 in 10^6 viruses. Another cell line,

CR2, was also made, which expresses the gH gene from the HSV-2 strain 25766. This also supports the growth of a DISC HSV-2 and also has no overlapping sequences between the virus and the cell.

Polymerase Chain Reaction (PCR) of Flanking Sequences

Viral DNA is purified from virus by standard methods. Flanking sequences to either side of the gH gene are amplified by PCR using Vent DNA polymerase (New England Biolabs) which has a lower error rate than Taq DNA polymerase (see Fig. 24). The oligonucleotides used for PCR include restriction site recognition sequences, as well as the specific viral sequences (see below). Two vectors are made, one for the first stage and one for the second stage of recombination. For both vectors the right hand flanking sequences start at the same position to the right of the gH gene. The first stage vector has left hand flanking sequences that, in addition to deleting the HSV-2 gH gene, also delete the 3' portion of the viral TK gene. The second stage vector has left hand flanking sequences which restor the complete TK gene, and extend right up to the 5' end of the gH gene, as desired in the final virus.

The oligonucleotides used are as follows:

		HindIII
MB97	TCGAAGCTTCAGGGAGTGGCGCAGC
		HpaI
MB96	TCAGTTAACGGACAGCATGGCCAGGTCAAG
		HpaI
MB57	TCAGTTAACGCCTCTGTTCCTTTCCCTTC

EcoRI
MB58 TCAGAATTCGAGCAGCTCCTCATGTTCGAC

Construction of Vectors

The first stage recombination vector, pIMMB47+

The two PCR fragments made by oligos MB97-MB96 and by oligos MB57-MB58 are digested with the restriction enzymes appropriate to the sites that have been included in the PCR oligonucleotides. The MB97-MB96 fragment is digested with HindIII and Hpal. The MB57-MB58 fragment is digested with Hpal and EcoRI. These fragments are then ligated into the vector pUC119 which has been digested with HindIII and EcoRI. The resultant plasmid is called pIMMB45 (see Fig. 24).

To allow for easy detection of the first stage recombinants, the E.coli beta-galactosidase gene, under the control of the Cytomegalovirus (CMV) immediate early promoter is inserted into pIMMB45. The CMV promoter plus beta-galactosidase gene is excised from a suitable plasmid carrying the promoter and gene using one or more appropriate restriction enzymes. If necessary, the ends are filled in using the Klenow fragment of DNA polymerase. This is the approach taken by the present applicants. However alternative methodologies will be apparent to those skilled in the art. For example, the beta-galactosidase gene may be under the control of the SV40 promoter, in which case, the gene and promoter can be excised from the plasmid pCH110 (Pharmacia PL Biochemicals) using BamHI and Tthlllı, and the ends are filled in using the Klenow

fragment of DNA polymerase (Ecob-Prince, M.S., et al 1993 J. Gen. Virol, 74, p. 985-994). The fragment is gel-purified. The plasmid pIMMB45 is digested with Hpal, phosphatased with Calf Intestinal Alkaline Phosphatase (CIAP) to abolish self ligation, and gel-purified. The gel-purified fragments are then ligated together to produce the plasmid pIMMB47+ (see Fig. 25).

The second stage recombination vector, pIMMB46

The two PCR fragments made by oligos MB94-MB109 and by oligos MB57-MB108 are digested with the restriction enzymes appropriate to the sites that have been included in the PCR oligonucleotides. The MB94-MB109 fragment is digested with HindIII and Hpal. The MB57-MB108 fragment is digested with Hpal and EcoRI. These fragments are then ligated into the vector pUC119 which has been digested with HindIII and EcoRI. The resultant plasmid is called pIIMB46 (see Fig. 26). The oligonucleotides used are as follows:

EcoRI
MB108 TCAGAATTCGTTCCGGGAGCAGGCGTGGA

MB109
Hpal
TCAGTTAACTGCACTAGTTTTAATTAATACGTATGCCGTCCGTCCCGGCTGCCAGTC

Construction of Recombinant Viruses

a) First Stage.

Virus DNA was made from strain HG52-D, which is a plaque-purified isolate of the HSV-2 strain HG52. Virus DNA (2.5 µg) and pIMMB47+ plasmid DNA (0.25 µg) was transfected into CR1 cells using the $CaPO_4$ precipitation method (Chen & Okayama, Molecular and Cellular Biology, 7,

p. 2745). Recombination takes place within the cells, and a mixture of recombinant and wild type virus is produced. The mixture was plaque-purified three times on CR1 cells in the presence of acyclovir (10 µg/ml), to select for TK-minus virus. A single plaque was then grown up and analysed. The virus was titrated on normal Vero cells and on CR1 cells. If the virus is a gH-deleted virus, it should only grow on CR1 cells and not on Vero cells. Table 1 shows that this is the case. It can be seen that the virus does not grow at all on the non-complementing Vero cells even at the highest virus concentrations, but does grow well on the CR1 complementing cell line, which expresses the HSV-1 gH gene. The virus also grows well on CR2 cells which express the HSV-2 gH gene (data not shown).

Table 1: growth of first stage recombinant virus on complementing (CR1) and non-complementing (Vero) cells.

	CR1 (gH+)			Vero			
Virus dilutions	10^{-4}	10^{-5}	10^{-6}	10^{-1}	10^{-2}	10^{-3}	10^{-4}
Numbers of plaques	>350	174	22	0	0	0	0
	>350	169	19	0	0	0	0

b) Second stage.

DNA was made from this TK-minus DISC virus and a recombination was carried out as above with the plasmid pIMMB46. In this case TK-plus recombinants were selected, on a gH-expressing TK-minus BHK cell line, by growth in medium containing methotrexate, thymidine, glycine,

adenosine and guanosine. Virus was harvested and grown again under selective conditions twice more before a final plaque purification was carried out on CR1. Virus was grown up and analysed by Southern blotting. Virus DNA from the original HG52-D, the TK-minus DISC virus, and the TK-plus DISC virus were digested with BamHI and separated on an agarose gel. The DNA bands were then transferred to nylon membrane by the Southern blotting method, and probed with radiolabelled fragments from the right hand flanking sequences. Fig. 27 shows the structures of these viruses, with the expected band sizes after BamHI digestion. The probe used is marked as 'R' beneath a dashed line. The probe should hybridise to a different size band in each of these viruses, as follows:

Virus	Band size hybridising (base pairs)
HG52-D	3481
TK-minus "first stage" DISC virus	3140
TK-plus "second stage" DISC virus	4225

Fig. 28 shows that this is the case. Lane 5 shows the HG52-D virus, Lane 2 contains the TK-minus "first stage" DISC virus, and lanes 3, 4, 6, 7 and 8 contain TK-plus "second stage" DISC viruses. This confirms that the DNA structure in each of these viruses is as expected.

The present application refers to certain strains of HSV-1 and HSV-2. It is not necessary that the general teaching contained herein is put into effect with precisely the mentioned strains. Strains of HSV-1 and HSV-2 having high sequence homology to one another by which the invention may be put into effect are readily available. For example, one source of HSV is the American Type Culture Collection (ATCC), 12301 Parklawn Drive, Rockville, Maryland 20852 USA. The following are available from ATCC under the indicated accession numbers.

HSV-1 strain F	:	ATCC accession no. VR-733
HSV-1 strain MacIntyre	:	ATCC accession no. VR-539
HSV-1 strain MP	:	ATCC accession no. VR-735
HSV-2 strain G	:	ATCC accession no. VR-734
HSV-2 strain MS	:	ATCC accession no. VR-540

IN VIVO MOUSE STUDIES

PROTECTION STUDIES

The in vivo mouse ear model was used to study prophylactic effects. Equivalent doses of inactivated wild-type HSV-1 (Strain SC16 see Hill et al. J. Gen. Virol. 28, p341-353 (1975)) and DISC HSV-1 were compared for their effect on the replication of w.t. HSV-1, their ability to provide protection against w.t. HSV-1 challenge and to induce HSV-specific neutralising antibodies.

4-5 week old BALB/c mice were vaccinated with varying doses of DISC HSV-1 or inactivated virus by scarification in the left ear pinna. Virus was inactivated using β-propiolactone (for further details see WO92/05263 published

on 2 April 1992 and incorporated herein by reference). The mice were challenged with 2 x 10^6 pfu w.t. HSV-1 (strain SC16) in the opposite ear two weeks after vaccination. The amount of virus present in that ear 5 days post challenge was assayed by plaquing on BHK cells. (See Fig. 2.)

It can be seen from Fig. 2 that vaccination with $5x10^5$ and $5x10^6$ pfu DISC HSV-1 (pfu measured on complementing cell line for DISC viruses) led to complete protection against replication of the challenge virus, whilst mice vaccinated with inactivated virus still had live challenge virus present.

A similar result was obtained when virus titres were assayed from the ganglia of vaccinated animals 5 days after challenge (data not shown).

SEROLOGICAL RESPONSE TO DISC HSV-1 VACCINATION

The role of antibody in protection conferred by the DISC HSV-1 vaccination was investigated. Both neutralising antibody titres and total antibody titres, as determined by ELISA, were measured.

Groups of 6 mice were vaccinated with $5x10^5$ pfu of DISC HSV-1, killed DISC HSV-1, w.t. HSV-1 (strain SC16) or with PBS and serum samples taken at 2 and 14 weeks post vaccination. Neutralising antibodies were measured in the presence of complement and expressed as the inverse of the serum dilution which reduced the number of plaques by 50%. ELISA antibody titres were measured on plates coated with HSV-1 infected BHK cell lysates and titrated to endpoint. (See Fig. 3.)

It can be seen from Fig. 3 that no significant differences in antibody titres were observed between animals vaccinated with DISC HSV-1 and an equivalent amount of killed DISC HSV-1.

DELAYED-TYPE HYPERSENSITIVITY (DTH) RESPONSE to DISC HSV-1 VACCINATION

The importance of a DTH response in protection against herpes virus infection has been well documented. The ability of the DISC HSV-1 to raise a DTH response was investigated by vaccinating groups of mice with DISC HSV-1, killed DISC HSV-1, and live w.t. HSV-1, by scarification of the left ear pinna.

Four doses ($5x10^3$, $5x10^4$, $5x10^5$ and $5x10^6$ pfu) of vaccine were used, and two weeks later the vaccinated animals were challenged in the opposite ear with 10^6 pfu w.t. HSV-1 (strain SC16). The DTH response at the site of challenge was assessed by measurement of ear thickness at 24 and 48 hours post challenge and expressed as the difference between the challenged and unchallenged ears. (See Fig. 4.)

It can be seen from Fig. 4 that at low vaccine doses ($5x10^3$, $5x10^4$ pfu), no DTH response was observed with killed DISC HSV-1, whilst a clear DTH response was demonstrated after DISC HSV-1 vaccination. At high doses (eg 5×10^6 pfu), both the DISC HSV-1 vaccine and killed DISC HSV-1 preparations induced similar DTH responses.

The DTH responses induced by different doses of the various vaccine preparations thus correlate with their

protective effect against challenge virus replication. The efficacy of vaccination with low doses of the DISC HSV-1 vaccine may therefore be due to the induction of T cell-mediated immunity.

DEMONSTRATION THAT DISC HSV TYPE 1 VIRUS IS CAPABLE OF GENERATING CYTOTOXIC T CELLS

Cytotoxic T cells have been shown to be involved in the protection against, and recovery from, primary HSV infection. DISC HSV-1 vaccinated mice were therefore studied for the presence of HSV-1 specific cytotoxic T cell activity.

Cytotoxic T cell activity following immunisation was generated and assayed according to standard procedures eg as exemplified in Martin, S. et al, 1988, J. Virol. 62: 2265-2273 and Gallichan, W.S. et al, J. Infect. Dis. 168: 633-629. More specifically, groups of female BALB/c mice were immunised intra-peritoneally with 2 x 10^7 pfu of virus (DISC HSV-1; killed DISC HSV-1; MDK a thymidine kinase negative HSV-1 strain) on day 0 and the immunisations repeated (same dose and route) after 3 weeks. A group of control mice received 0.1ml of PBS intraperitoneally at the same time points. Ten days after the second immunisation the spleens of the mice were removed and pooled for each group.

Spleens were also removed from unimmunised BALB/c mice for the preparation of feeder cells (16 feeder spleens being sufficient for 4 groups of six effector spleens). All subsequent steps were performed in a laminar flow hood

using aseptic technique. The spleens were passed through a sterile tea-strainer to produce a single cell suspension in RPMI 1640 medium supplemented with 10% heat inactivated foetal calf serum (effector medium). Debris was allowed to settle and the single cell suspension was transferred to a fresh container. The cell suspensions were washed twice in effector medium (1100 rpm, 10 minutes) and then passed through sterile gauze to remove all clumps. The effector spleen cell suspensions were then stored on ice until required.

Feeder spleen cells were resuspended to 1 x 10^7 cells/ml in effector medium and mitomycin C was added to a final concentration of 20µg/ml. The feeder cells were incubated at 37°C for 1 hour. Feeder cells were washed four-times in PBS supplemented with 1% FCS and once in PBS with no protein. Live virus (MDK) was added to the mitomycin C treated feeder cell pellet at a concentration of 3 pfu of virus per spleen cell. Following a one hour incubation at 37°C the feeder cells were washed once with effector cell medium.

Effector cells were resuspended to 5 x 10^6 cells/ml, whilst feeder cells were resuspended to 2.5 x 10^6 cells/ml. 500µl of effector cell suspension and 500µl feeder cell suspension were added to the wells of a 24 well plate. The plates were incubated in a humid atmosphere at 37°C (5% CO_2) for 4 days.

The effector and feeder cells were harvested from the 24 well plate. The cells were spun down once and the pellet resuspended in effector medium (5ml of medium per 2

plates). The cell suspension was layered onto lymphocyte separation medium and spun at 2500rpm for 20 minutes. The live effector cells were harvested from the interface and washed twice, once at 1500 rpm for 15 minutes and once at 1100 rpm for 10 minutes. The effector cells were finally resuspended at the required concentration in effector medium and stored on ice until required.

Labelled target cells were prepared for the cytotoxicity assay. Uninfected syngeneic A202J target cells A20/2J cells were harvested from tissue culture flasks; 2 x 10^7 cells were added to each of 2 containers (to become infected and uninfected targets). The cells were washed with DMEM (with no additions). To the infected cells live MDK virus was added at 10pfu per cell and an equivalent volume of EMEM was added to the uninfected cells. One mCi of 51Cr was added to each of the universals and the cells were incubated at 37°C (in a waterbath) for 1 hour. The target cells were then washed three times (10 minutes, 1100rpm) in target medium (DMEM supplemented with 10% FCS) and finally resuspended to the required cell concentration in target cell medium.

Both uninfected and infected target cells were resuspended to 1 x 10^6 cells/ml and 1 x 10^5 cells/ml and 100µl (ie to give 1 x 10^5 targets/well and 1 x 10^4 targets/well respectively) was plated out into the appropriate wells of a round bottomed 96 well plate. All experimental points were set up in quadruplicate. Each effector cell type was resuspended to 8 x 10^6 cells/ml in effector medium and two-fold dilutions were prepared.

100µl of the effector cell suspensions were added to the wells containing the labelled target cells to give 8 x 10^5 effector cells/well, 4 x 10^5 effector cells/well, 2 x 10^5 effector cells/well and 1 x 10^5 effector cells/well. Thus with 10^5 target cells per well, effector to target ratios were: 8:1, 4:1, 2:1 and 1:1. With 10^4 target cells per well the effector to target ratios were 80:1, 40:1, 20:1 and 10:1. Maximum chromium release for each target cell type was obtained by adding 100µl of 20% Triton X-100 to wells containing target cells only (ie no effectors). The spontaneous release for each target cell type was obtained by the addition of 100µl effector cell medium to wells containing target cells only.

The plates were incubated at 37°C for four hours in a humid atmosphere. After this time the plates were spun for four minutes at 1500rpm and 100µl of supernatant was removed from each of the wells. The supernatant was transferred to LP2 tubes and radioactivity contained in the tubes was then counted for 1 minute on a gamma counter. The % specific chromium release was determined using the formula

$$\% \text{ specific release} = \frac{\text{Exp. mean cpm - spon. mean cpm}}{\text{Max. mean cpm - spon. mean cpm}} \times 100$$

Exp. = Experimental

Spon. = Spontaneous

Max. = Maximum

The results are shown in Fig. 5 and Table 1

Table 1

E:T ratio	DISC HSV-1	Inactivated Virus	MDK	Unvaccinated
8:1	53.9	1.5	48.3	ND
4:1	49.6	0.0	42.2	0.0
2:1	36.9	0.0	31.0	0.0
1:1	23.9	0.0	21.9	0.0

% HSV-1 Specific Lysis

(% lysis of HSV-infected cells minus % lysis of uninfected cells).

DISC HSV-1 vaccination induced HSV-1 specific CTL activity comparable to that produced by infection with the fully replicative MDK virus. In contrast no HSV-1 specific CTL activity was observed in mice immunised with killed DISC HSV-1 or in PBS treated animals, although some non-specific killing was observed in these animals. The reason for this is not clear, but it could represent a high level of NK cell activity.

Vaccination of mice with the DISC HSV-1 has thus been shown to induce antibody, CTL and DTH activity against HSV-1 virus antigens. The ability to activate both humoral and cell-mediated immune responses against a broad spectrum of virus proteins may explain the effectiveness of the DISC virus vaccination.

LONG-TERM PROTECTION

The in vivo mouse ear model was used to study long term prophylactic effect of DISC HSV-1

4-5 week old BALB/c mice were divided into groups containing 6 animals each. The groups were vaccinated as follows:

Group	Vaccination
PBS	Mock immunisation with PBS
1K	1 immunisation with inactivated DISC HSV-1
2K	2 immunisations with inactivated DISC HSV-1
1L	1 immunisation with (live) DISC HSV-1
2L	2 immunisations with (live) DISC HSV-1
1S	1 immunisation with w.t. HSV-1 (strain SC16)
2S	2 immunisations with w.t. HSV-1 (strain SC16)

All groups were immunised by scarification of the left ear pinna with 5 x 10^5 pfu on day 0 and blood samples taken on days 15, 27, 90, 152 and 218. Groups PBS, 2K, 2L and 2S received additional immunisations of PBS or 5 x 10^5 pfu on day 20. All groups were challenged with 5 x 10^5 w.t. HSV-1 (strain SC16) on day 223. The amount of virus present in the challenged ear (right) 5 days post challenge was assayed by plaquing on BHK cells. The results as depicted by Fig. 14 show that two vaccinations with DISC HSV-1 (group 2L) provides goods protection compared to inactivated DISC HSV-1 (group 2K), but that better protection was obtained with w.t. HSV-1 (strain SC16). The efficacy of vaccination with w.t. HSV-1 is of course, to be expected. However the use of normal live viruses as vaccines is generally undesirable. Fig. 15 shows the neutralising antibody titres induced by the various vaccinations. This shows that since 2 doses of DISC HSV-1

produce the same titre as two doses of the inactivated DISC HSV-1, the protective effect of DISC HSV-1 cannot be simply explained by antibody induction.

PROPHYLACTIC EFFECT OF DISC HSV-2

The in vivo mouse ear model was used to study the prophylactic effect of DISC HSV-2.

Six week old BALB/c mice were divided into groups. They were immunised by scarification of the left ear pinna as follows.

Group	Vaccination Material and Dose
1	5×10^2 pfu live DISC HSV-2
2	5×10^3 pfu live DISC HSV-2
3	5×10^4 pfu live DISC HSV-2
4	5×10^5 pfu live DISC HSV-2
5	5×10^2 pfu killed DISC HSV-2
6	5×10^3 pfu killed DISC HSV-2
7	5×10^4 pfu killed DISC HSV-2
8	5×10^5 pfu killed DISC HSV-2
9	5×10^4 pfu w.t. HSV-2 (strain HG52)
10	5×10^5 pfu w.t. HSV-2 (strain HG52)
11	PBS

The DISC HSV-2 was a gH deletion mutant of strain HG52

Three weeks later, all groups were challenged by scarification of the right ear pinna with 5×10^4 of w.t. HSV-2 (strain HG52).

The amount of virus present in the challenged ear (right) 5 days post challenge was assayed by plaquing on BHK cells (see Fig. 16). The results as depicted by the figure show that vaccination with DISC HSV-2 at doses of 5×10^3, 5×10^4 and 5×10^5 pfu provides good protection against challenge with w.t. HSV-2 (strain HG52) compared to killed DISC HSV-2. However and as is to be expected, better protection was obtained with w.t. HSV-2 at doses of

5 x 10^4 and 5 x 10^5 pfu, but the use of normal live wild type viruses as vaccines is undesirable.

IN VIVO GUINEA PIG STUDIES

As mentioned earlier, HSV-2 appears to be closely associated with genital lesions. The guinea pig currently provides the best animal model for primary and recurrent genital disease in humans (Stanberry, L.R. et al. J. Inf. Dis. 1982, 146, 397-404).

Therefore the applicants have extended the earlier described mouse studies to the guinea pig vaginal model of HSV-2 infection which provides a useful system to assess the immunogenicity of candidate vaccines against genital HSV-2 infection in humans. It permits a comprehensive assessment of primary clinical symptoms following intra-vaginal challenge with HSV-2, and also analysis of the frequency of subsequent recurrences.

(1) Groups of 14 animals were immunised with two doses of the DISC HSV-1 vaccine (2 x 10^7 pfu, 3 weeks apart) either by non-traumatic introduction into the vagina (intra-vaginal route), or by scarification of the ear pinna (intra-epithelial route). A control group of 21 animals was vaccinated intra-vaginally with a mock virus preparation and a further group of 14 animals was vaccinated intra-epithelially with two equivalent doses of β-propiolactone-inactivated w.t. HSV-1.

Vaccinated animals were challenged 3 weeks later with $10^{5.2}$ pfu w.t. HSV-2 virus (strain MS) and monitored for the symptoms of primary and recurrent disease.

(a) Following w.t. HSV-2 challenge, animals were assessed daily over a two week period for symptoms of primary infection. Clinical lesions were scored as a direct numerical value, and erythema was scored on a scale of 1-5. The vaginal area was also measured as an index of oedema (data not shown). The results are shown in Figs. 6 and 7. Points on the graphs represent mean erythema score per animal per day (Fig. 6) and mean total lesion score per day per animal (Fig. 7).

The results show that intra-epithelial and intra-vaginal vaccination with the DISC HSV-1 both provided a high degree of protection against the primary symptoms of HSV-2 infection. Surprisingly, inactivated HSV-1 administered by the intra-epithelial route also provided substantial protection, though apparently less than that afforded by the DISC virus vaccine.

(b) Daily vaginal swabs were taken from all animals over a 12 day period post-challenge and virus titres determined by plaquing on Vero cells in order to monitor growth of the challenge virus in the vagina. The results as depicted in Fig. 8 shows that infection virus titres in mock-vaccinated animals rose to a maximum of 3×10^4 at day 2 post challenge, and could be detected until day 10. By contrast, virus titres in the vaccinated animals declined steadily from day 1, and were undetectable by day 7. No significant different was observed between the groups immunised with the DISC HSV-1 or the inactivated virus preparation.

(c) Following HSV-2 challenge, animals which had fully recovered from the acute phase of disease by 28 days were monitored daily for a further 100 days for the recurrence of disease. Numbers of animals in each group were: DISC/Intra-vaginal -14; DISC/Intra-epithelial -12; Inactivated/Intra-epithelial -14; Mock/Intra-vaginal -12. Clinical lesions were scored as a direct numerical value, and erythema was scored on a scale of 1-5. The results are shown in Figs. 9a and 9b. Points on the graphs represent the cumulative totals of mean values per day per animal.

The results show that animals vaccinated with the DISC HSV-1 by the intra-vaginal route showed approximately a 50% reduction in the number of recurrent HSV-2 lesions occurring over the 100 day follow-up period. Intra-epithelial vaccination with DISC HSV-1 and inactivated virus also resulted in a reduction of recurrent lesions, but to a lesser extent.

(2) The following experiment was also designed to assess the immunogenicity of candidate DISC vaccines based on HSV-1 against genital HSV-2 infection. The experiment was designed to compare different vaccination routes (per vaginum, oral and nasal ie different mucosal surfaces) and different doses of either DISC HSV-1 or inactivated HSV-1 in the guinea pig.

Materials and Methods

Virus.

(i) DISC HSV-1 was propagated on Vero cells (F6)

which had been transfected with the HSV-1 gH gene as described previously in WO92/05263 published on 2 April 1992. Briefly, confluent monolayers of F6 cells were infected with DISC HSV-1 at a multiplicity of 0.1 pfu per cell and harvested when 90-100% cpe was observed. Cells were harvested with a cell scraper, pelleted by centrifugation and the pellet resuspended in a small volume of Eagles Minimum Essential Medium (EMEM). The suspension was sonicated for 1 minute and stored in aliquots at -70°C. Virus titres were determined on F6 cells.

(ii) DISC HSV-1 was inactivated by the addition of β-propiolactone at a concentration of 0.05% for one hour at room temperature. Inactivation was checked by adding the virus to F6 cells.

(iii) HSV-2 strain MS was propagated and titred on Vero cells in the same manner as DISC HSV-1 as described above.

Animals

Female Dunkin-Hartley guinea-pigs (300-350g) were obtained from Davis Hall, Darley Oaks Farms, Newchurch, Nr. Burton-on-Trent.

Experimental design

Groups of 12 animals were immunised with two doses of 8×10^6 pfu DISC HSV-1 or with equivalent doses of inactivated DISC HSV-1, on days 1 and 17 of the experiment. Immunisation was performed with either 0.05 ml of virus intravaginally, with 0.2 ml of virus intranasally or with 0.2 ml virus orally. A control group of 12 animals was vaccinated intravaginally with a mock preparation of virus

consisting of sonicated Vero cells. All groups were challenged intravaginally on day 34 with $10^{5.2}$ pfu HSV-2 (strain MS) and the experiment blinded by randomisation of the cages by an independent worker. For a period of 11 days following challenge, animals were monitored for the symptoms of primary disease. Clinical observations were scored as the number of lesions present in the vaginal area and the presence of erythema (scored on a scale of 1-5). In addition, daily vaginal swabs were taken from all animals over a 12 day period post challenge and virus titres were determined by plaquing on Vero cells in order to monitor growth of the challenge virus in the vagina.

Statistical methods

Differences in group clinical scores were tested for significance using the Mann-Whitney U test. Values of $p<0.1$ were considered significant.

Results

Clinical disease profile.

The mean lesion score per animal, the mean erythema score and the effect of vaccination on post challenge virus replication for each of the immunisation groups are shown in Figs 10, 11 and 12 respectively. As compared to mock vaccinated animals, vaccination with DISC HSV-1 by the intravaginal route provided a high degree of protection from primary symptoms of infection. In contrast, vaccination with inactivated DISC HSV-1 at an equivalent dose did not lead to any significant protection.

Intranasal immunisation with DISC HSV-1 resulted in an even higher degree of protection than intravaginal

vaccination. This was particularly apparent when looking at the number of days with severe disease, as defined by a lesion score of 6 or more (see table 2). Inactivated DISC HSV-1 gave some protection via the intranasal route, but it was not as effective as vaccination with DISC HSV-1.

Vaccination via the oral route also led to protection, but to a lesser degree than intranasal or intravaginal vaccination. Again vaccination with DISC HSV-1 virus protected more efficiently than vaccination with inactivated DISC HSV-1.

Table 2

INCIDENCE OF PRIMARY DISEASE SYMPTOMS

Immunisation with	Any disease symptoms (% of animals)	Lesion score >5 (% of animals)	Duration of disease (mean no. days)	Disease ongoing on day 11 (% of animals)
mock	92	75	6.8	75
DISC HSV-1 i.vag	33	17	4.5	8
HSV-1 inactivated i.vag	92	67	6.2	83
DISC HSV-1 i.nas	33	0	2.3	0
HSV-1 inactivated i.nas	67	17	6.3	42
DISC HSV-1 oral	90	20	4.1	20
HSV-1 inactivated oral	91	36	5.8	64

Thus the following conclusions can be drawn from this experiment with the in vivo guinea pig model.

A. Vaccination with DISC HSV-1 via the intravaginal and intranasal routes led to a high degree of protection from acute disease symptoms following a challenge with HSV-2.

B. Intranasal administration of DISC HSV-1 gave the highest degree of protection when considering the number of days of severe disease (as defined by the presence of 6 or more lesions).

C. Intravaginal vaccination with inactivated virus resulted in clinical disease symptoms similar to those observed in mock-infected guinea-pigs. Intranasal vaccination with inactivated DISC HSV-1 gave a significant degree of protection, but not as high as DISC HSV-1 vaccination via this route.

D. A significant difference was observed between disease symptoms in animals vaccinated orally with DISC HSV-1 and mock-infected animals. However, this degree of protection was less than that observed in animals vaccinated with DISC HSV-1 via the intranasal or intravaginal route.

E. Symptoms in animals vaccinated orally with inactivated DISC HSV-1 were not significantly different from those in the mock-infected group.

F. The data on shed virus is interesting. Surprisingly the per vaginum vaccination route resulted in significantly lower levels of recovered

virus following the challenge dose. This may be due to local antibody production.

(3) The following experiment was designed to investigate HSV-2 induced recurrent disease following therapeutic vaccination.

This was of interest as it has previously been shown that therapeutic administration of certain recombinant HSV-2 antigens, together with adjuvant, can decrease the frequency of subsequent recurrences. (Stanberry, L.R. et al. J. Inf. Dis. 1988; 157, p156-163; Stanberry, L.R. et al. J. Gen. Virol. 1989a; 70 p3177-3185; Ho, R.J.Y. et al, J. Virol. 1989; 63p 2951-2958).

Accordingly 21 animals which had recovered fully from primary HSV-2 disease four weeks after challenge were randomised into three groups, and treated with live DISC HSV-1 intravaginally (10 animals), or intra-epithelially (11 animals). A group of 12 animals, which had previously acted as controls for prophylactic vaccination (see (2) above) and which had also recovered fully from primary disease were treated with an equivalent mock preparation (12 animals). The animals were given further identical treatments 24 and 48 days later. The frequency of recurrent disease was monitored from the day of first treatment for a further 100 days, and the cumulative results are shown in Fig. 13 and summarised in Table 3 below.

Table 3 - Effect of therapeutic vaccination on recurrent disease

	Mock		DISC HSV-1 Intra-epithelial		DISC HSV-1 Intra-vaginal	
	Total	% of Mock	Total	% of Mock	Total	% of Mock
1 Mean total disease/days per animal	9.41	100	6.90	73	7.32	78
2 Mean total episodes per animal	6.27	100	4.67	74	5.10	81
3 Disease incidence	12/12	100	9/11	82	10/10	100
4 Severity per episode	3.21	100	3.00	93	2.86	89
Mean duration of episode (days)	1.49		1.27		1.38	

1 Total number of days where disease was observed (either lesions or erythema) over the whole observation period (100 days from 1 month after challenge with HSV-2)

2 Total of days disease episodes over the whole observation period (episode length defined as period between two consecutive disease-free days

3 Proportion of animals showing any lesion or erythema score during whole observation period

4 Total sum of erythema scores and lesion numbers over the whole observation period divided by number of episodes observed

It can be seen that each of the groups treated with DISC HSV-1 appeared to experience a modest reduction (about 25%) in the overall number of disease/days and episodes especially over the 50 day period following second vaccination.

Sera were collected from these animals at the end of the 100 day observation period. The ELISA and NT antibody titres in the sera were not significantly higher than those recorded post-challenge but before therapeutic treatment and there were no significant differences in titres between the mock-treatment group and the DISC HSV-1 treated groups.

Thus therapeutic administration of DISC HSV-1 virus either intra-vaginally or intra-epithelially resulted in an apparent reduction (20-25%) in the frequency of recurrence compared with mock-treated animals.

(4) The following experiment was designed to investigate the therapeutic value of a DISC virus based on HSV-2. A DISC HSV-2 (strain HG 52) having a deletion of the gH gene was made as described earlier and in accordance with the general teaching of WO92/05263 published on 2 April 1992 and incorporated herein by reference and also using standard procedures in the art. The DISC version of the strain was grown in Vero cells transfected with the HSV-2 gH gene also in accordance with the teaching of WO92/05263.

The experiment was a head to head comparison of DISC HSV-1 with DISC HSV-2 in female 350-400 gms guinea-pigs.

Guinea-pigs were divided into three groups. All guinea-pigs were infected with $10^{5.8}$ pfu HSV-2 strain MS. Four weeks were then allowed for the primary disease to have both developed and resolved and for recurrences to have started. The animals were then treated. A first group of 15 animals was treated intravaginally with a mock preparation of virus consisting of sonicated Vero cells. A second group of 13 animals was treated intravaginally with 10^7 pfu DISC HSV-1. A third group of 14 animals was treated intravaginally with 10^7 pfu DISC HSV-2. Treatment was repeated in 14 days.

The results are shown in Table 4. Days 1-13 covers the period between the two treatments. Days 14-27 covers the two week period subsequent to the second treatment. Days 1-27 covers the complete period.

As shown by the results, it appears that treatment with DISC HSV-2 was effective in alleviating symptoms caused by infection with HSV-2 strain MS. Treatment with DISC HSV-2 was more effective than treatment with DISC HSV-1.

Table 4

Group	Erythema scores			Lesions scores			Disease Days		
	Total	Per animal	% of Mock	Total	Per animal	% of Mock	Total	Per animal	% of Mock
Days 1-13									
Mock	38	2.53	100	66	4.40	100	42	2.80	100
DISC HSV-1	34	2.62	103	48	3.69	84	34	2.62	93
DISC HSV-2	22	1.57	62	40	2.86	65	26	1.86	66
Days 14-27									
Mock	13	0.87	100	23	1.53	100	17	1.13	100
DISC HSV-1	9	0.69	80	14	1.08	70	11	0.85	75
DISC HSV-2	2	0.14	16	3	0.21	14	3	0.21	19
Days 1-27									
Mock	51	3.40	100	89	5.93	100	59	3.93	100
DISC HSV-1	43	3.31	97	62	4.77	80	45	3.46	88
DISC HSV-2	24	1.71	50	43	3.07	52	29	2.07	53

CLAIMS

1. A pharmaceutical which comprises a mutant non-retroviral virus whose genome is defective in respect of a gene essential for the production of infectious virus such that the virus can infect normal cells and undergo replication and expression of viral antigen genes in those cells but cannot produce normal infectious virus, for prophylactic or therapeutic use in generating an immune response in a subject infected therewith.

2. A pharmaceutical according to claim 1, wherein the defect allows the production and release from the cells of non-infectious viral particles.

3. A pharmaceutical which comprises a mutant non-retroviral virus whose genome is defective in respect of a gene essential for the production of infectious virus such that the virus can infect normal cells and replicate therein to give rise to the production and release from the cells of non-infectious viral particles.

4. A pharmaceutical according to any one of the preceding claims which is a vaccine capable of protecting a patient immunised therewith against infection or the consequences of infection with a non-retroviral virus.

5. A pharmaceutical according to any one of the preceding claims which is a therapeutic capable of treating a patient

with an established non-retroviral virus infection.

6. A pharmaceutical according to claim 4 or claim 5 which is capable of protecting against infection or the consequences of infection, or treating a patient for infection by the corresponding wild-type virus.

7. An epithelially-administrable pharmaceutical according to according to any one of claims 1 to 6 which comprises an excipient for epithelial administrations.

8. A nasally-administrable pharmaceutical according to any one of claims 1 to 6 which comprises an excipient for nasal administration.

9. A vaginally-administrable pharmaceutical according to any one of claims 1 to 6 which comprises an excipient for vaginal administration.

10. An orally-administrable pharmaceutical according to any one of claims 1 to 6 which comprises an excipient for oral administration.

11. A pharmaceutical according to any one of claims 1 to 10 wherein the mutant is from a double-stranded DNA virus.

12. A pharmaceutical according to claim 11 wherein the mutant is from a herpes virus.

13. A pharmaceutical according to claim 12 wherein the mutant is from herpes simplex virus (HSV).

14. A pharmaceutical according to claim 13 wherein the mutant is a type-1 HSV.

15. A pharmaceutical according to claim 13 wherein the mutant is a type-2 HSV.

16. A pharmaceutical according to claim 14 or claim 15 wherein the defect is in the glycoprotein gH gene.

17. Use of a mutant type-1 HSV whose genome is defective in respect of a gene essential for the production of infectious HSV-1 such that the virus can infect normal cells and undergo replication and expression of viral antigen genes in those cells but cannot produce normal infectious virus, for preparation of a pharmaceutical for prophylactic or therapeutic use in generating an immune response in a subject against type-2 HSV infection.

18. Use according to claim 17 wherein the pharmaceutical is for epithelial administration.

19. Use according to claim 17 wherein the pharmaceutical is for vaginal administration.

20. Use according to claim 17 wherein the pharmaceutical is for nasal administration.

21. Use according to claim 17 wherein the pharmaceutical is for oral administration.

22. An assembly comprising a pharmaceutical according to any one of claims 1 to 16 in a container with printed instructions on or accompanying the container concerning the administration of the pharmaceutical to a patient to protect against or treat conditions caused by infection with a non-retroviral virus.

23. An assembly according to claim 22 wherein the non-retroviral virus is a double-stranded DNA virus.

24. An assembly according to claim 23 wherein the double-stranded DNA virus is a herpes virus.

25. An assembly according to claim 24 wherein the herpes virus is a herpes simplex virus (HSV).

26. An assembly according to claim 25 wherein the HSV is type 1.

27. An assembly according to claim 26 wherein the HSV is type 2.

28. An assembly according to claim 26 wherein the printed instructions concern protection against or treatment of facial lesions.

29. An assembly according to claim 27 wherein the printed instructions concern protection against or treatment of genital lesions.

30. Use of a pharmaceutical according to any one of claims 1 to 16 to generate an anti-non-retroviral virus immune response in a patient for prophylactic or therapeutic purposes.

31. Use according to claim 30 wherein the non-retroviral virus is a double-stranded DNA virus.

32. Use according to claim 31 wherein the double-stranded DNA virus is a herpes virus.

33. Use according to claim 32 wherein the herpes virus is a herpes simplex virus (HSV).

34. Use according to claim 33 wherein the HSV is type 1.

35. Use according to claim 34 wherein the HSV is type 2.

36. Use according to claim 34 for the prophylaxis or treatment of facial lesions in a patient.

37. Use according to claim 35 for the prophylaxis or treatment of genital lesions in a patient.

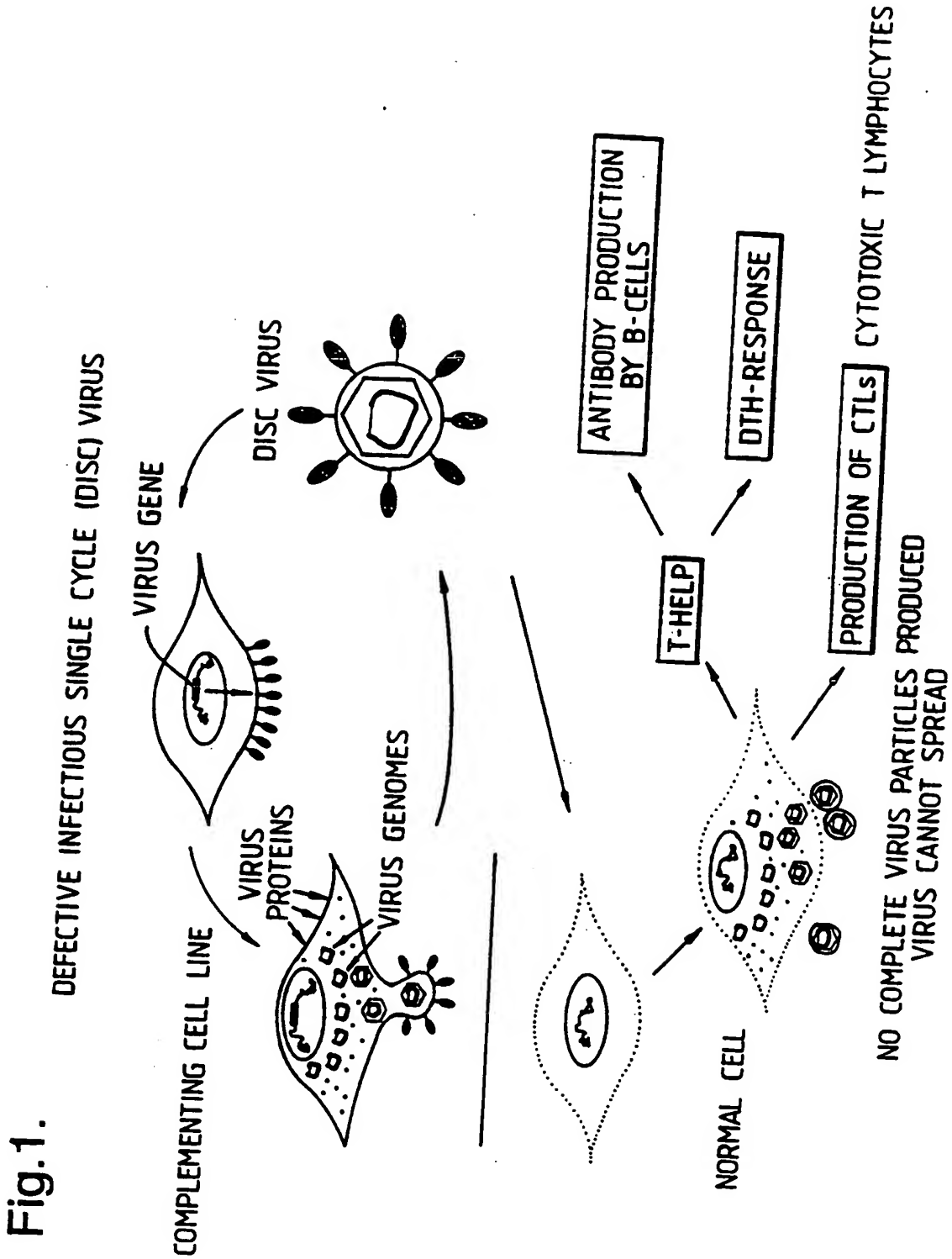

DEFECTIVE INFECTIOUS SINGLE CYCLE (DISC) VIRUS
VIRUS GENE
DISC VIRUS
COMPLEMENTING CELL LINE
VIRUS PROTEINS
VIRUS GENOMES
ANTIBODY PRODUCTION BY B-CELLS
DTH-RESPONSE
T-HELP
PRODUCTION OF CTLs
CYTOTOXIC T LYMPHOCYTES
NORMAL CELL
NO COMPLETE VIRUS PARTICLES PRODUCED
VIRUS CANNOT SPREAD

Fig.1.

Fig.2

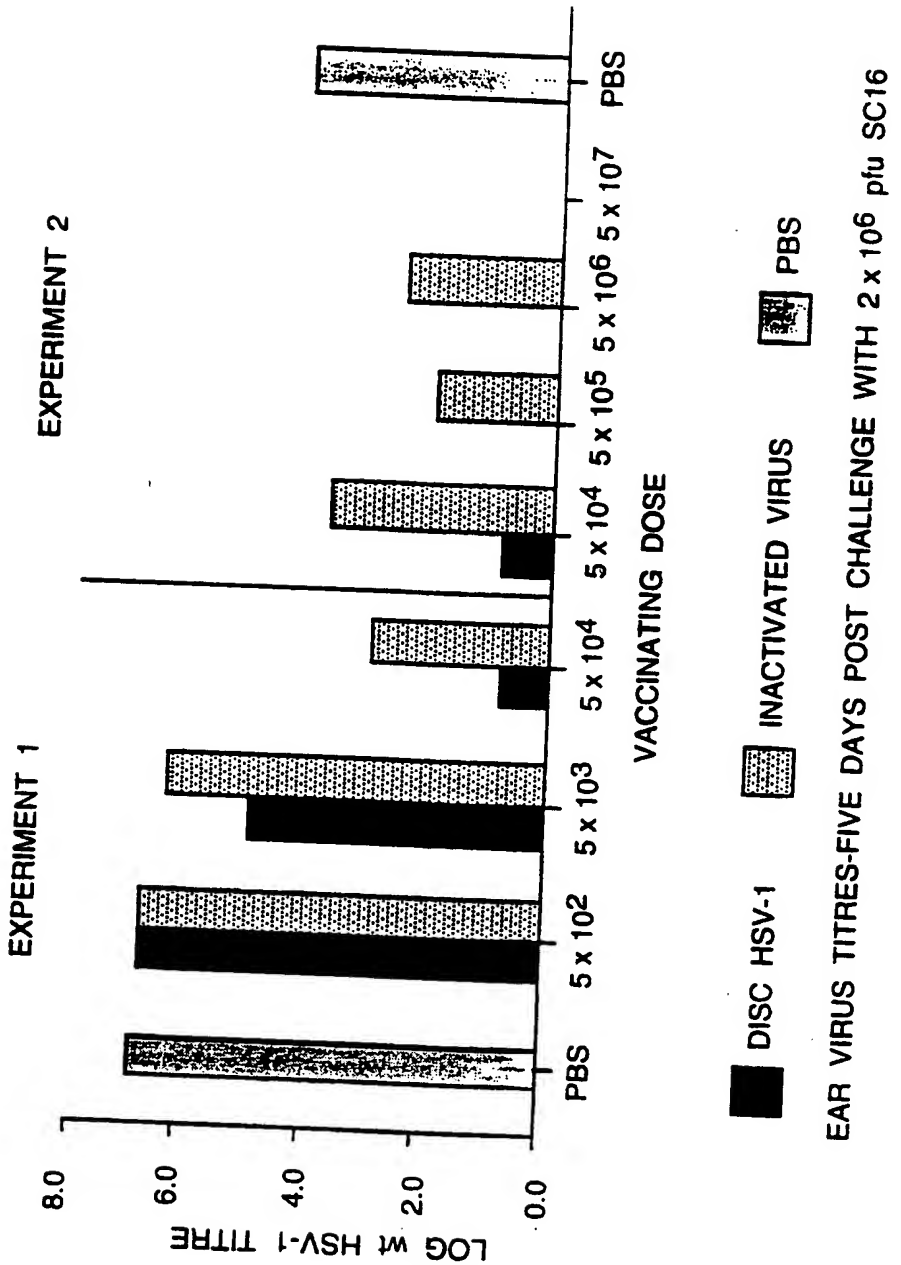

EAR VIRUS TITRES-FIVE DAYS POST CHALLENGE WITH 2 x 10^6 pfu SC16
DISC HSV-1
INACTIVATED VIRUS
PBS
LOG wt HSV-1 TITRE
8.0
6.0
4.0
2.0
0.0
EXPERIMENT 1
EXPERIMENT 2
PBS
5 x 10^2
5 x 10^3
5 x 10^4
5 x 10^4
5 x 10^5
5 x 10^6
5 x 10^7
PBS
VACCINATING DOSE

Fig.3

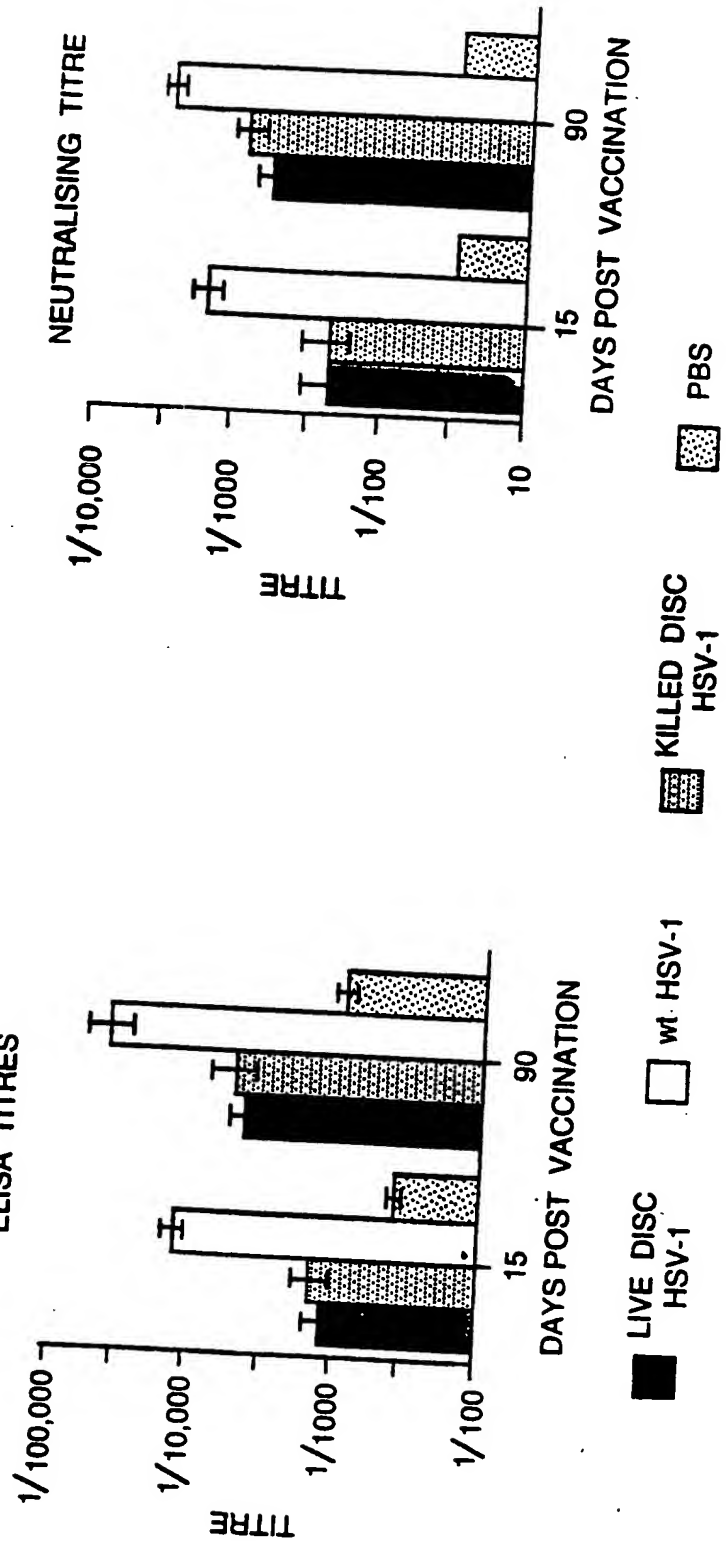

NEUTRALISING TITRE
1/10,000
1/1000
1/100
10
TITRE
15
90
DAYS POST VACCINATION
KILLED DISC HSV-1
PBS
ELISA TITRES
1/100,000
1/10,000
1/1000
1/100
TITRE
15
90
DAYS POST VACCINATION
LIVE DISC HSV-1
wt HSV-1

Fig.4

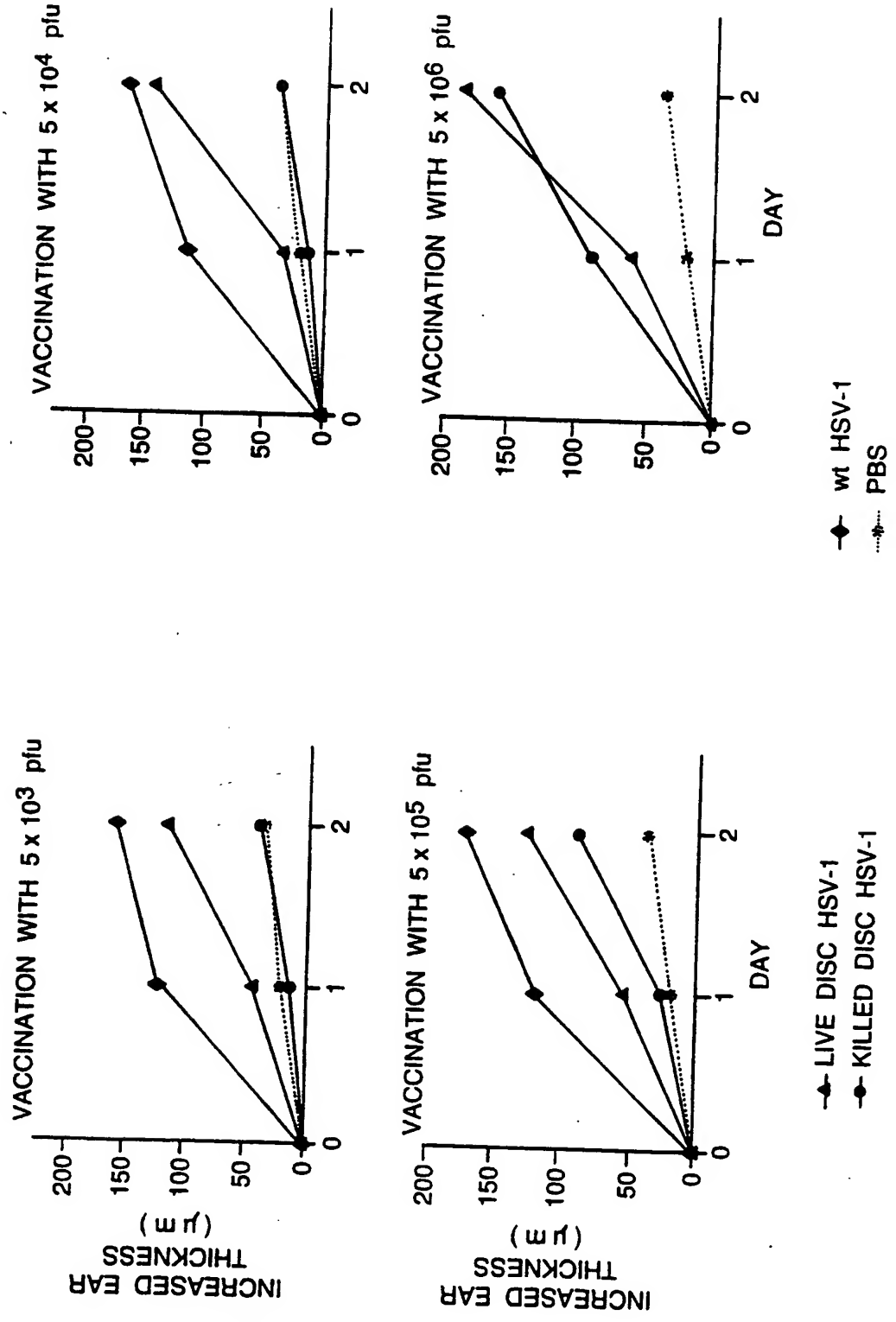

VACCINATION WITH 5 x 10³ pfu
VACCINATION WITH 5 x 10⁴ pfu
VACCINATION WITH 5 x 10⁵ pfu
VACCINATION WITH 5 x 10⁶ pfu
INCREASED EAR THICKNESS (μm)
DAY
0
50
100
150
200
1
2
LIVE DISC HSV-1
KILLED DISC HSV-1
wt HSV-1
PBS

Fig.5

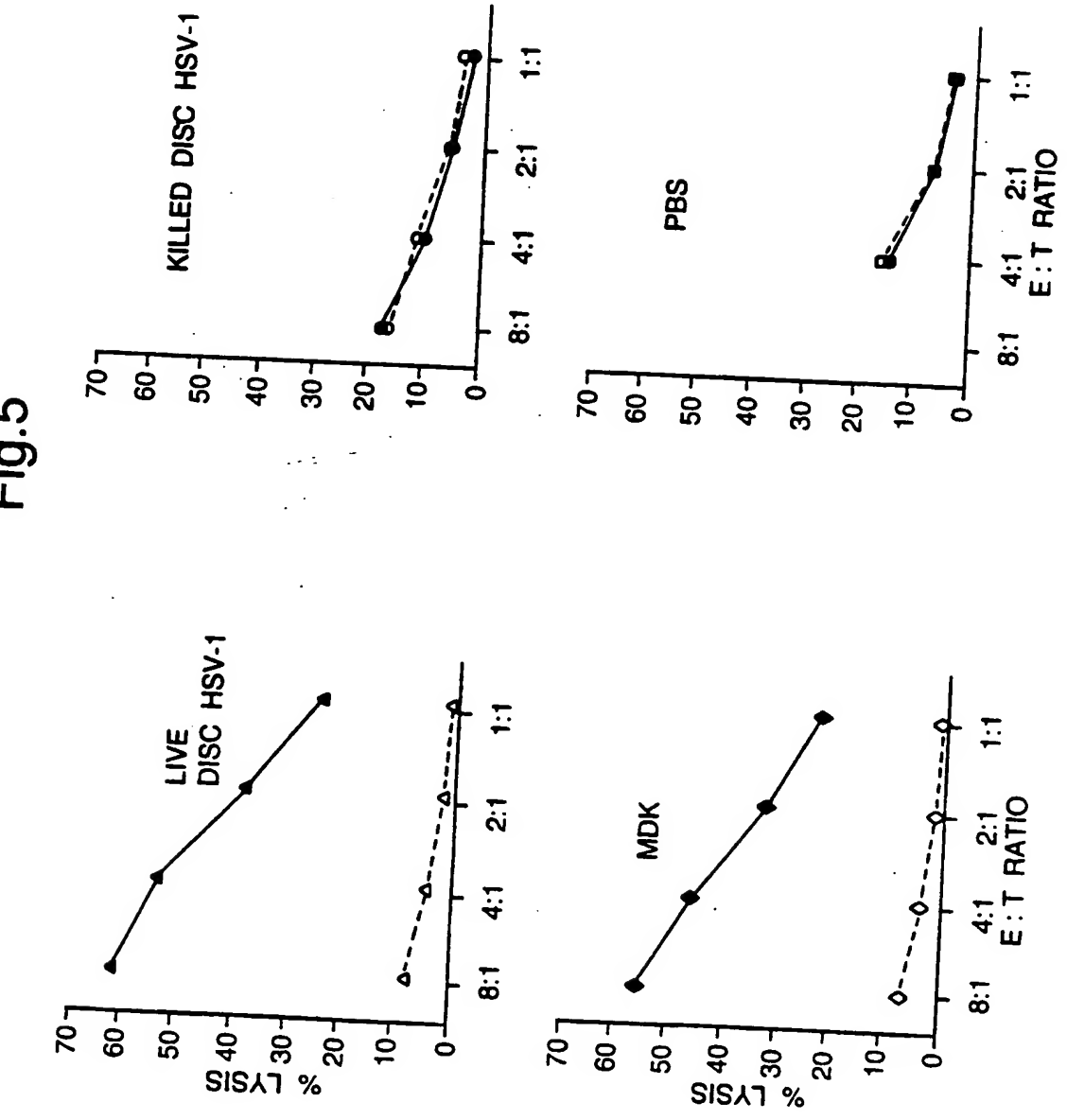

IMMUNISATION WITH
TARGET
LIVE DISC HSV-1
INFECTED
LIVE DISC HSV-1
UNINFECTED
KILLED DISC HSV-1
INFECTED
KILLED DISC HSV-1
UNINFECTED
MDK
INFECTED
MDK
UNINFECTED
PBS
INFECTED
PBS
UNINFECTED
KILLED DISC HSV-1
PBS
LIVE DISC HSV-1
MDK
% LYSIS
E:T RATIO
8:1
4:1
2:1
1:1
0
10
20
30
40
50
60
70

Fig.6

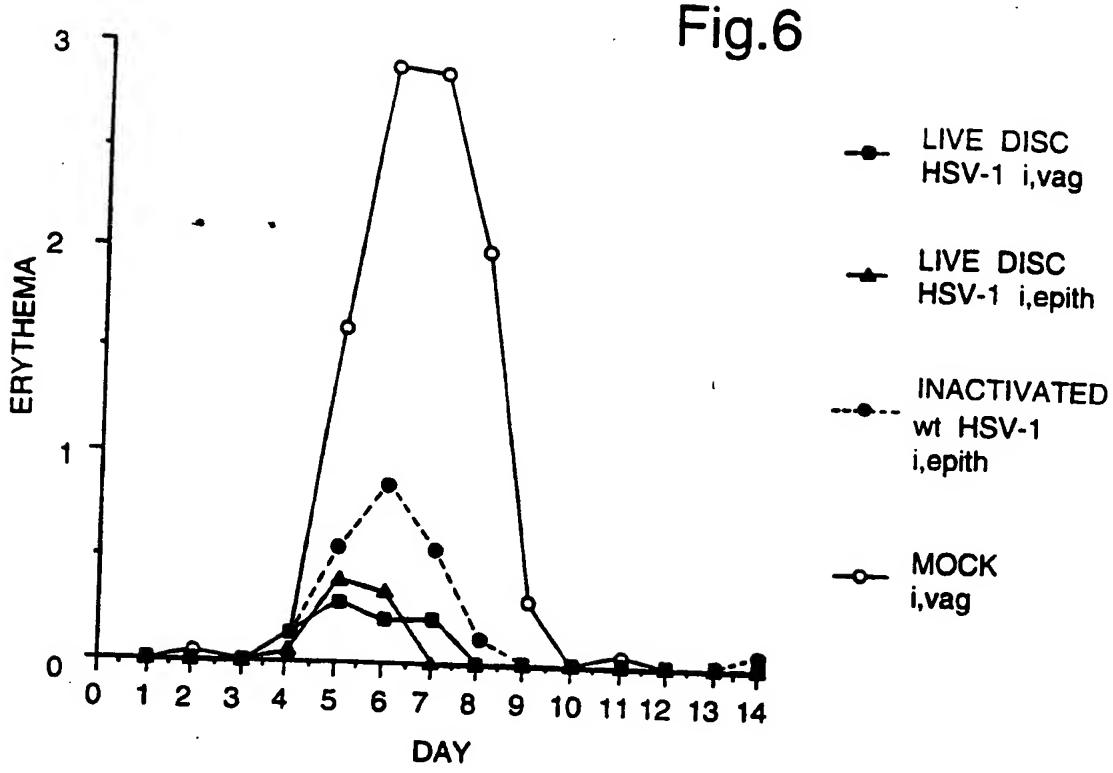

ERYTHEMA
0
1
2
3
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
DAY
LIVE DISC HSV-1 i,vag
LIVE DISC HSV-1 i,epith
INACTIVATED wt HSV-1 i,epith
MOCK i,vag

Fig.7

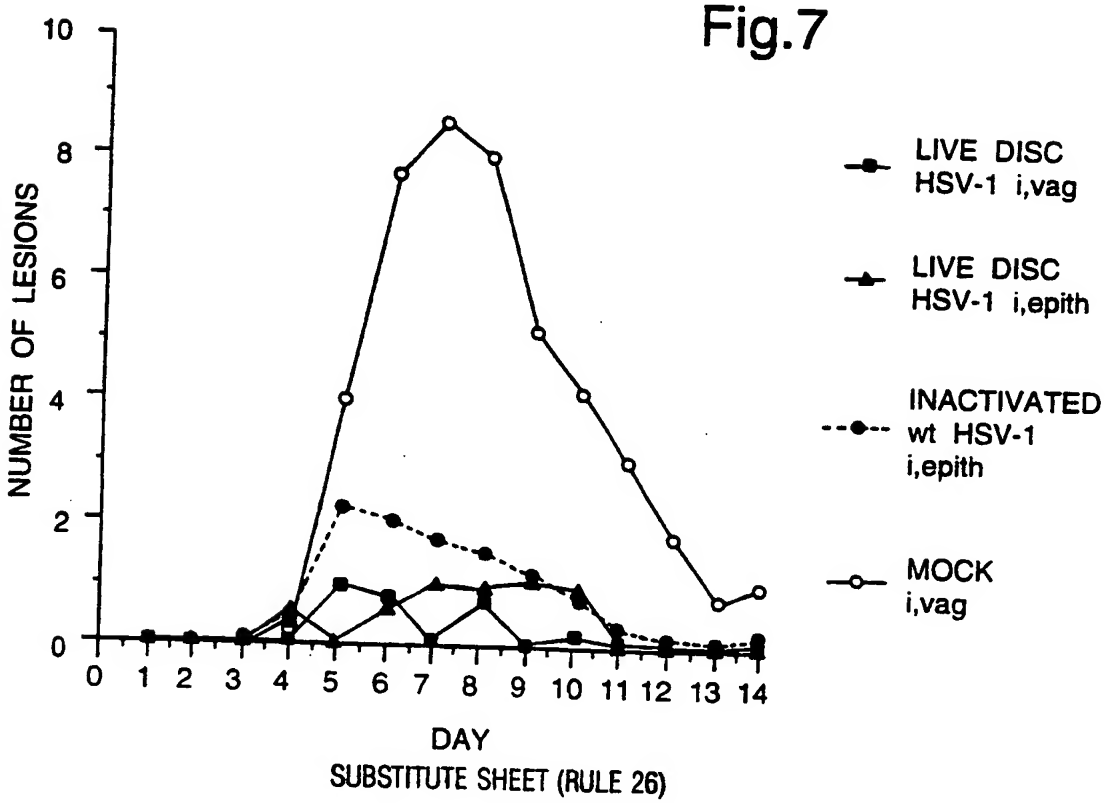

NUMBER OF LESIONS
0
2
4
6
8
10
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
DAY
LIVE DISC HSV-1 i,vag
LIVE DISC HSV-1 i,epith
INACTIVATED wt HSV-1 i,epith
MOCK i,vag

Fig.8

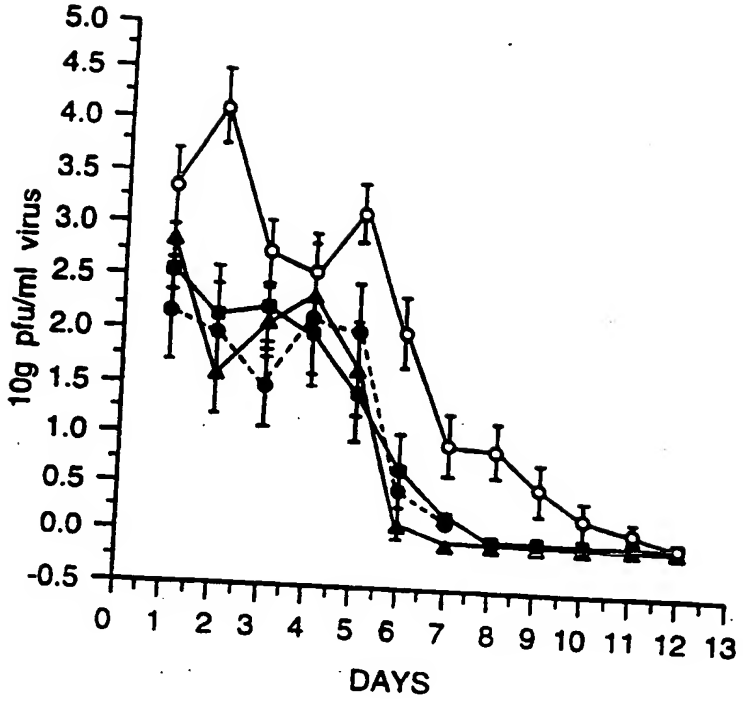

5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
10g pfu/ml virus
0 1 2 3 4 5 6 7 8 9 10 11 12 13
DAYS
LIVE DISC HSV-1 i,vag
LIVE DISC HSV-1 i,epith
INACTIVATED wt HSV-1 i,epith
MOCK i,vag

Fig.9a

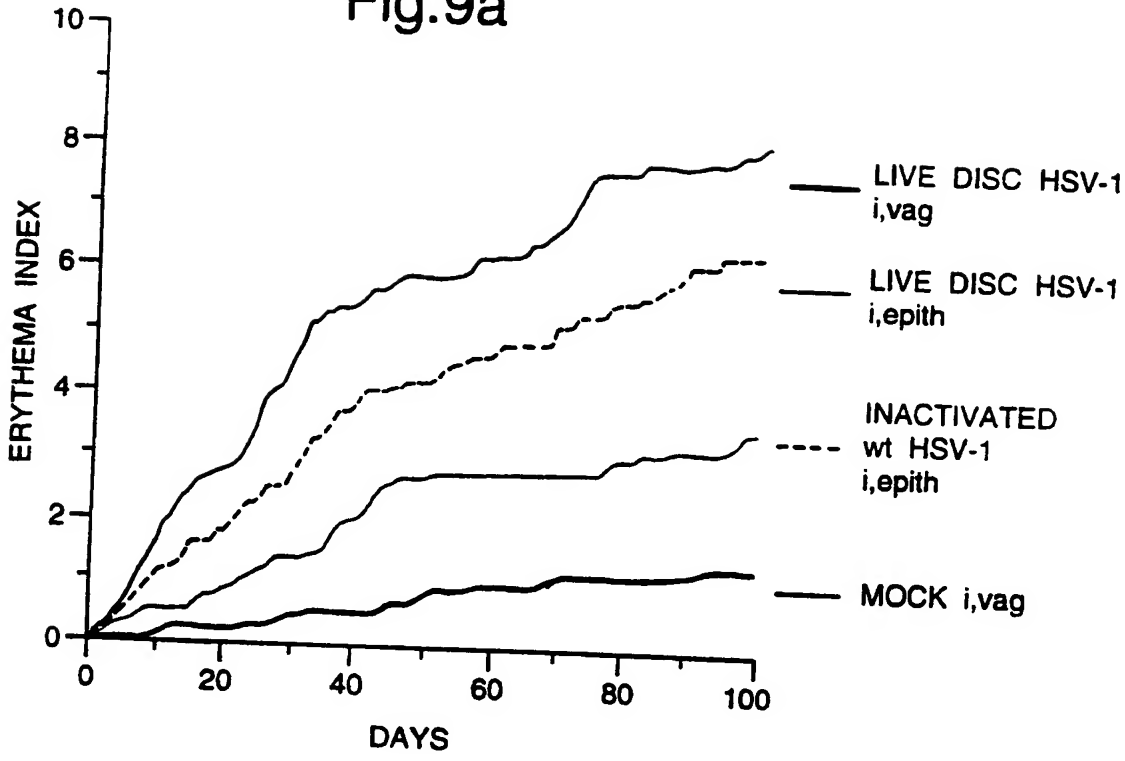

ERYTHEMA INDEX
10
8
6
4
2
0
0
20
40
60
80
100
DAYS
LIVE DISC HSV-1 i,vag
LIVE DISC HSV-1 i,epith
INACTIVATED wt HSV-1 i,epith
MOCK i,vag

Fig.9b

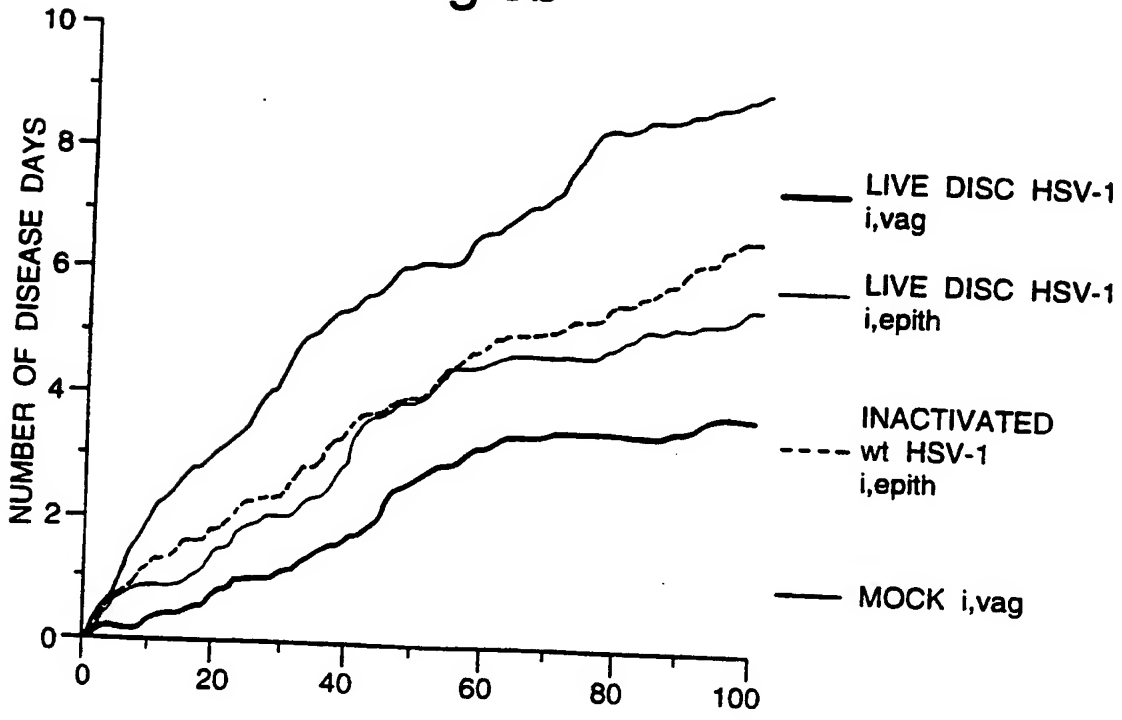

NUMBER OF DISEASE DAYS
10
8
6
4
2
0
0
20
40
60
80
100
DAYS
LIVE DISC HSV-1 i,vag
LIVE DISC HSV-1 i,epith
INACTIVATED wt HSV-1 i,epith
MOCK i,vag

Fig.10

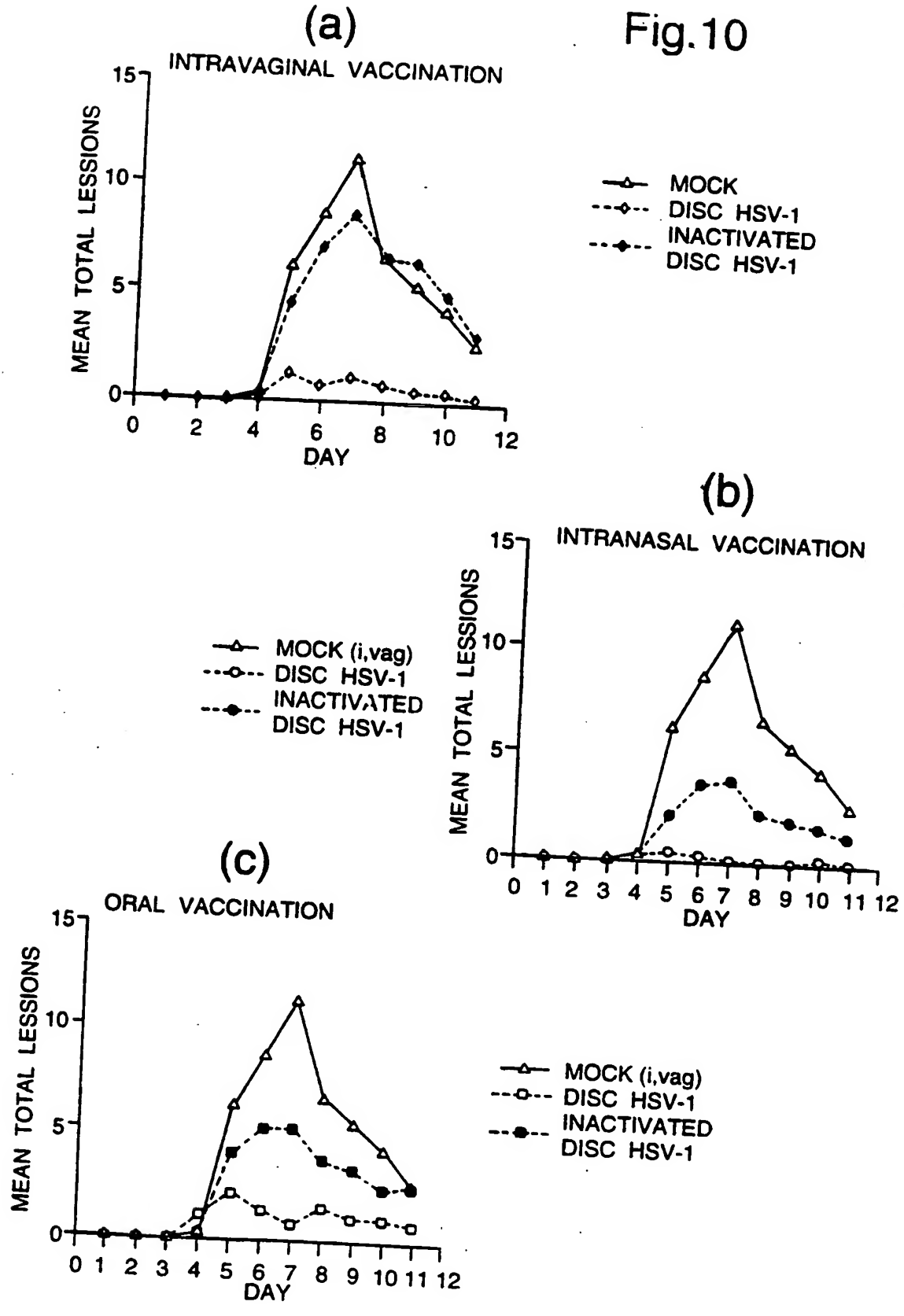
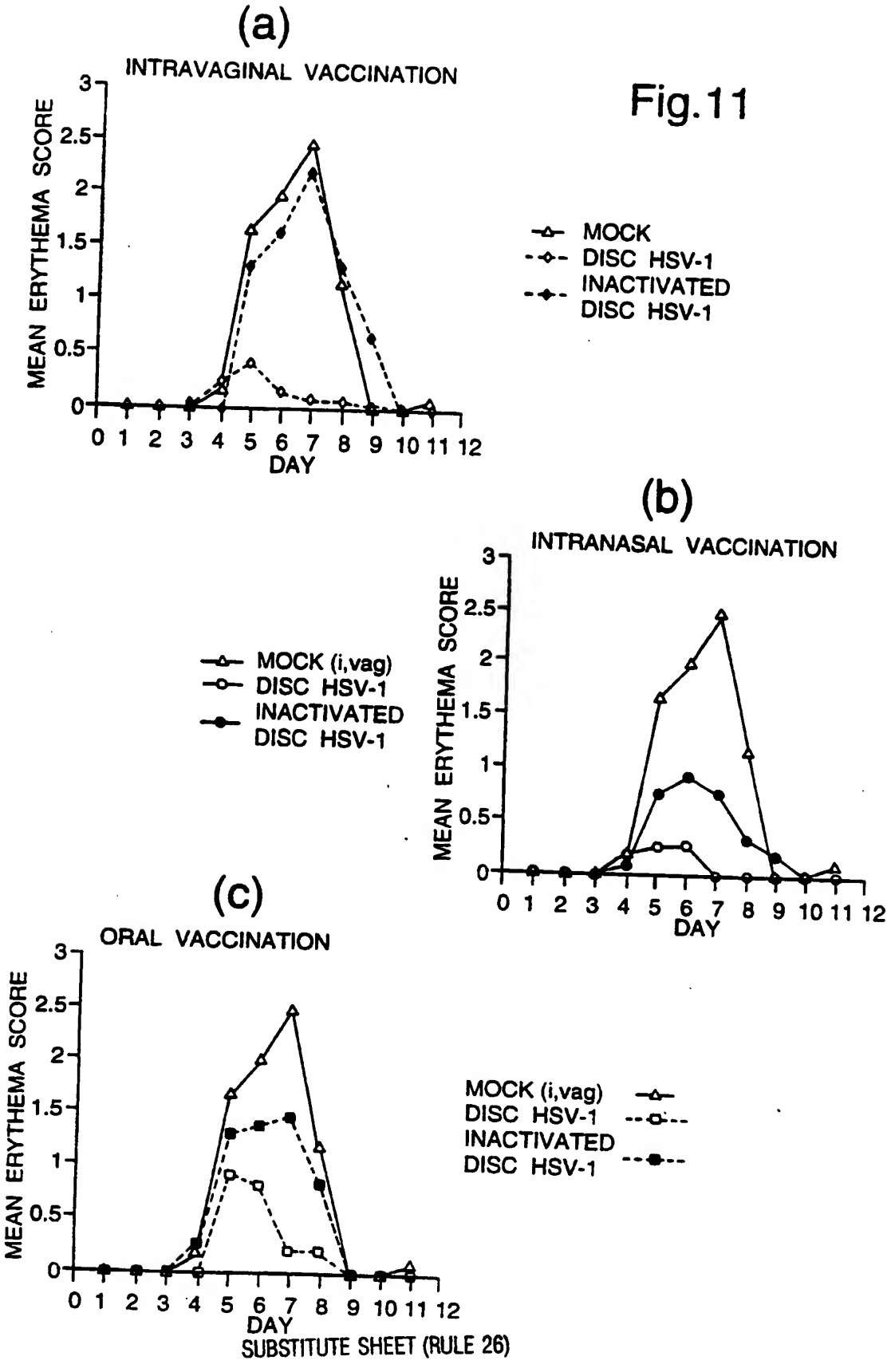
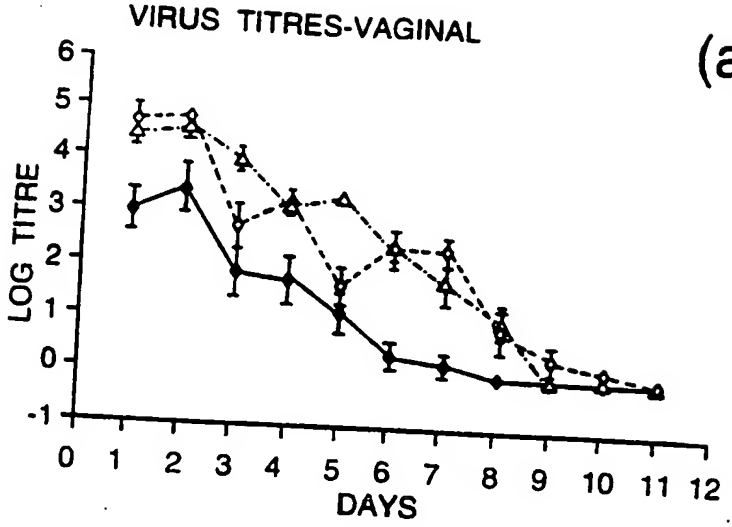
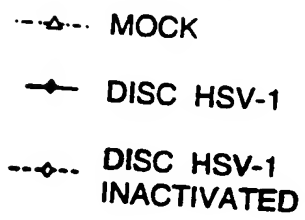

(a)
INTRAVAGINAL VACCINATION
MEAN TOTAL LESSIONS
DAY
MOCK
DISC HSV-1
INACTIVATED DISC HSV-1
(b)
INTRANASAL VACCINATION
MEAN TOTAL LESSIONS
DAY
MOCK (i,vag)
DISC HSV-1
INACTIVATED DISC HSV-1
(c)
ORAL VACCINATION
MEAN TOTAL LESSIONS
DAY
MOCK (i,vag)
DISC HSV-1
INACTIVATED DISC HSV-1

Fig.11

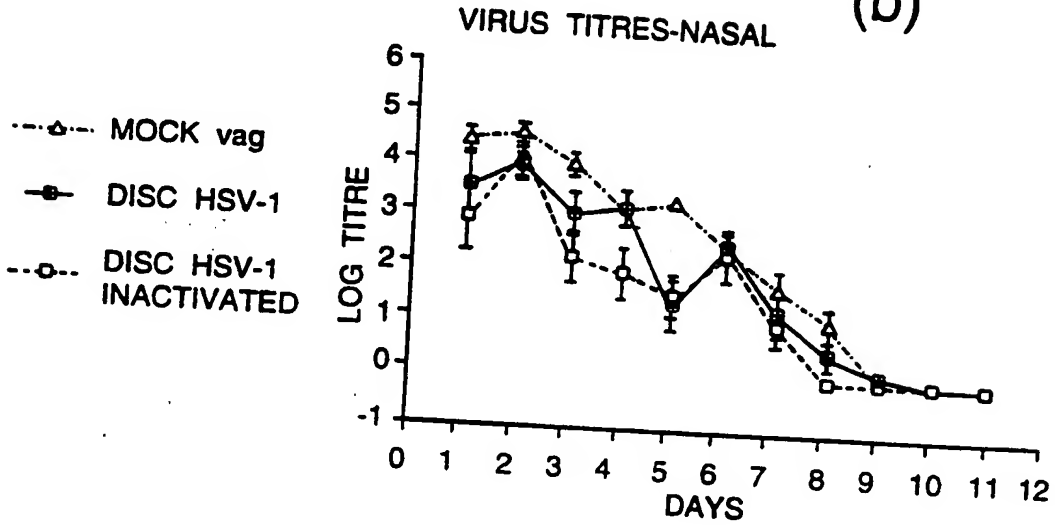

(a)
INTRAVAGINAL VACCINATION
MEAN ERYTHEMA SCORE
DAY
MOCK
DISC HSV-1
INACTIVATED DISC HSV-1
(b)
INTRANASAL VACCINATION
MEAN ERYTHEMA SCORE
DAY
MOCK (i,vag)
DISC HSV-1
INACTIVATED DISC HSV-1
(c)
ORAL VACCINATION
MEAN ERYTHEMA SCORE
DAY
MOCK (i,vag)
DISC HSV-1
INACTIVATED DISC HSV-1

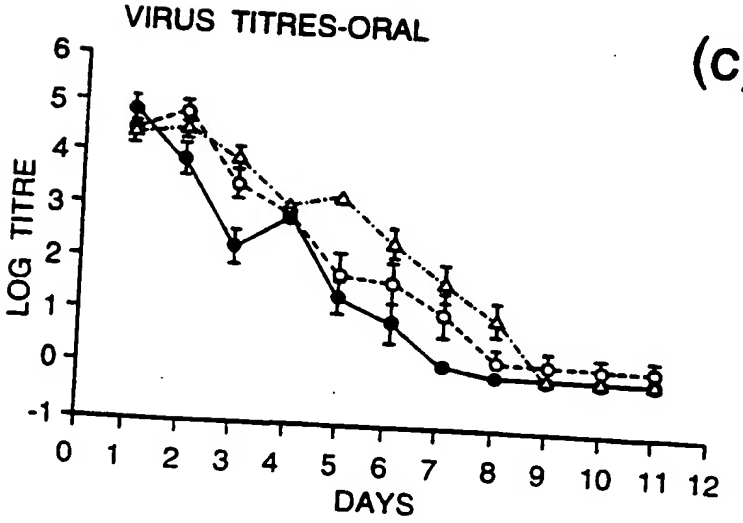

VIRUS TITRES-VAGINAL
LOG TITRE
DAYS
6
5
4
3
2
1
0
-1
0 1 2 3 4 5 6 7 8 9 10 11 12

(a) Fig.12


MOCK
DISC HSV-1
DISC HSV-1
INACTIVATED

(b)


VIRUS TITRES-NASAL
MOCK vag
DISC HSV-1
DISC HSV-1
INACTIVATED
LOG TITRE
DAYS
6
5
4
3
2
1
0
-1
0 1 2 3 4 5 6 7 8 9 10 11 12


VIRUS TITRES-ORAL
LOG TITRE
DAYS
6
5
4
3
2
1
0
-1
0 1 2 3 4 5 6 7 8 9 10 11 12

(c)

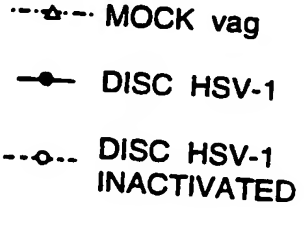

MOCK vag
DISC HSV-1
DISC HSV-1
INACTIVATED

Fig.13

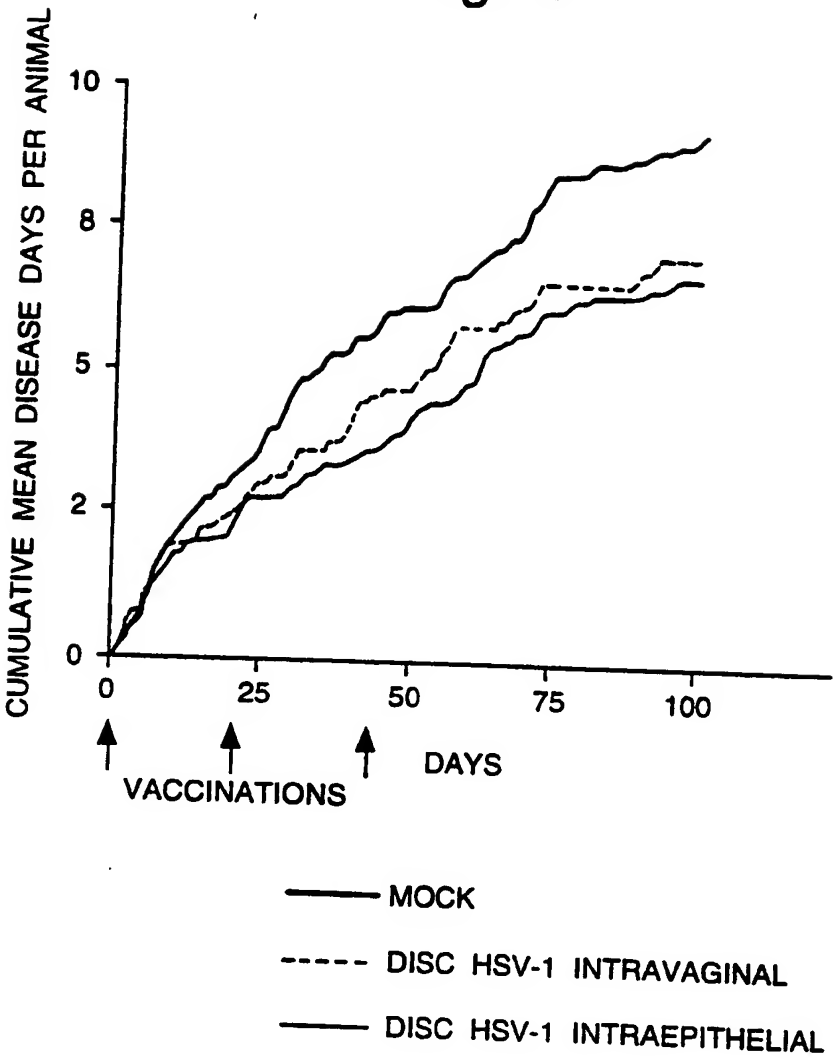

CUMULATIVE MEAN DISEASE DAYS PER ANIMAL
10
8
5
2
0
0
25
50
75
100
DAYS
VACCINATIONS
MOCK
DISC HSV-1 INTRAVAGINAL
DISC HSV-1 INTRAEPITHELIAL

Fig.14

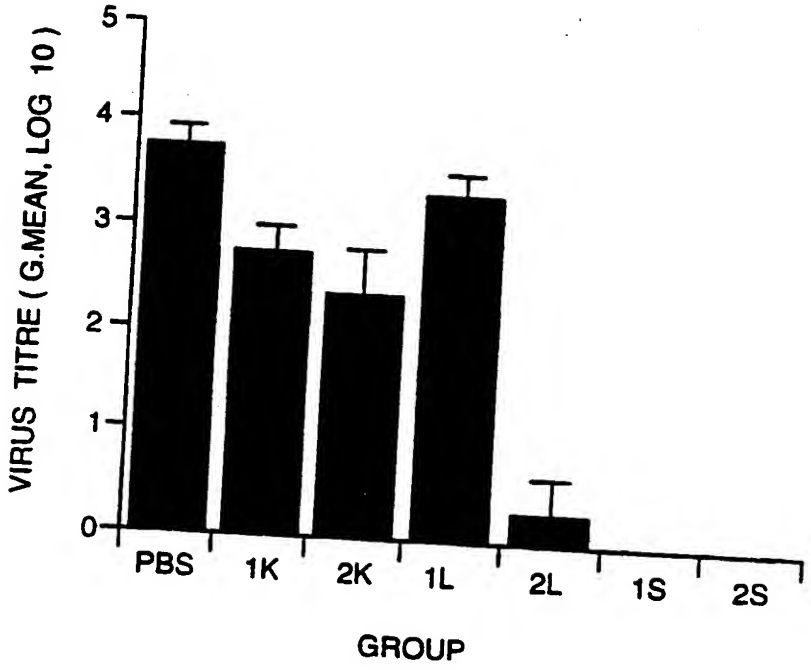


Fig.15

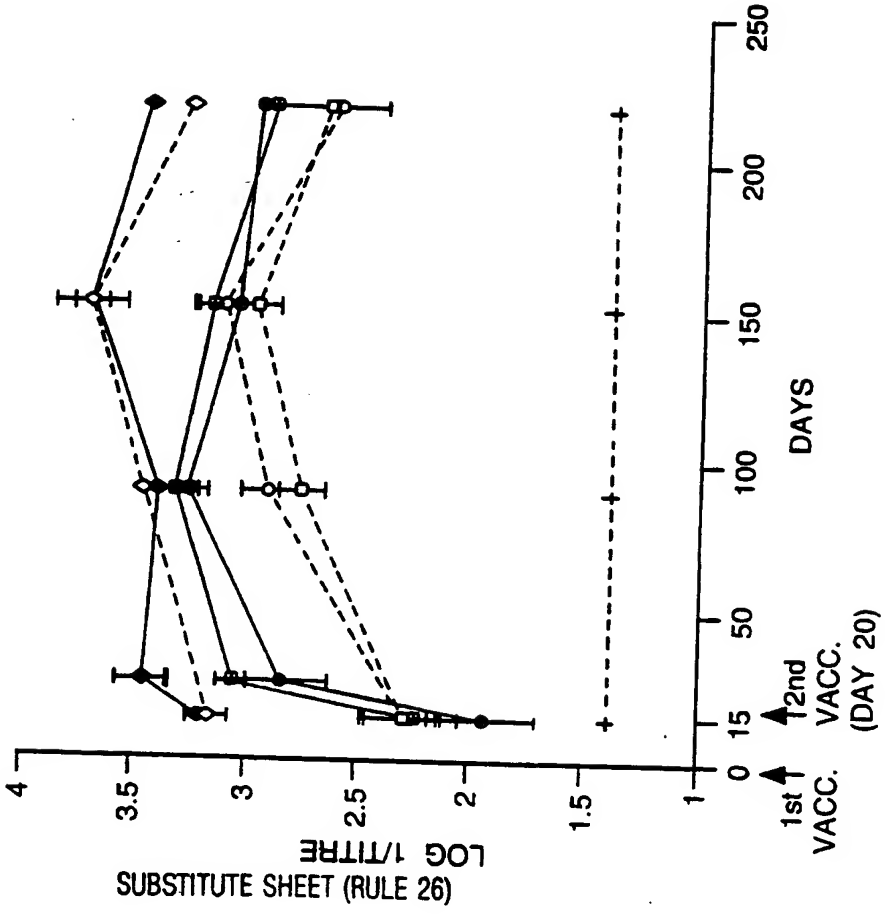

1 VACCINATION LIVE DISC HSV-1
1 VACCINATION INACTIVATED DISC HSV-1
1 VACCINATION wt HSV-1 (SC16)
1 VACCINATION PBS
2 VACCINATIONS LIVE DISC HSV-1
2 VACCINATIONS INACTIVATED DISC HSV-1
2 VACCINATIONS wt HSV-1 (SC16)
LOG 1/TITRE
4
3.5
3
2.5
2
1.5
1
0
15
50
100
150
200
250
DAYS
1st VACC.
2nd VACC. (DAY 20)

Fig.16

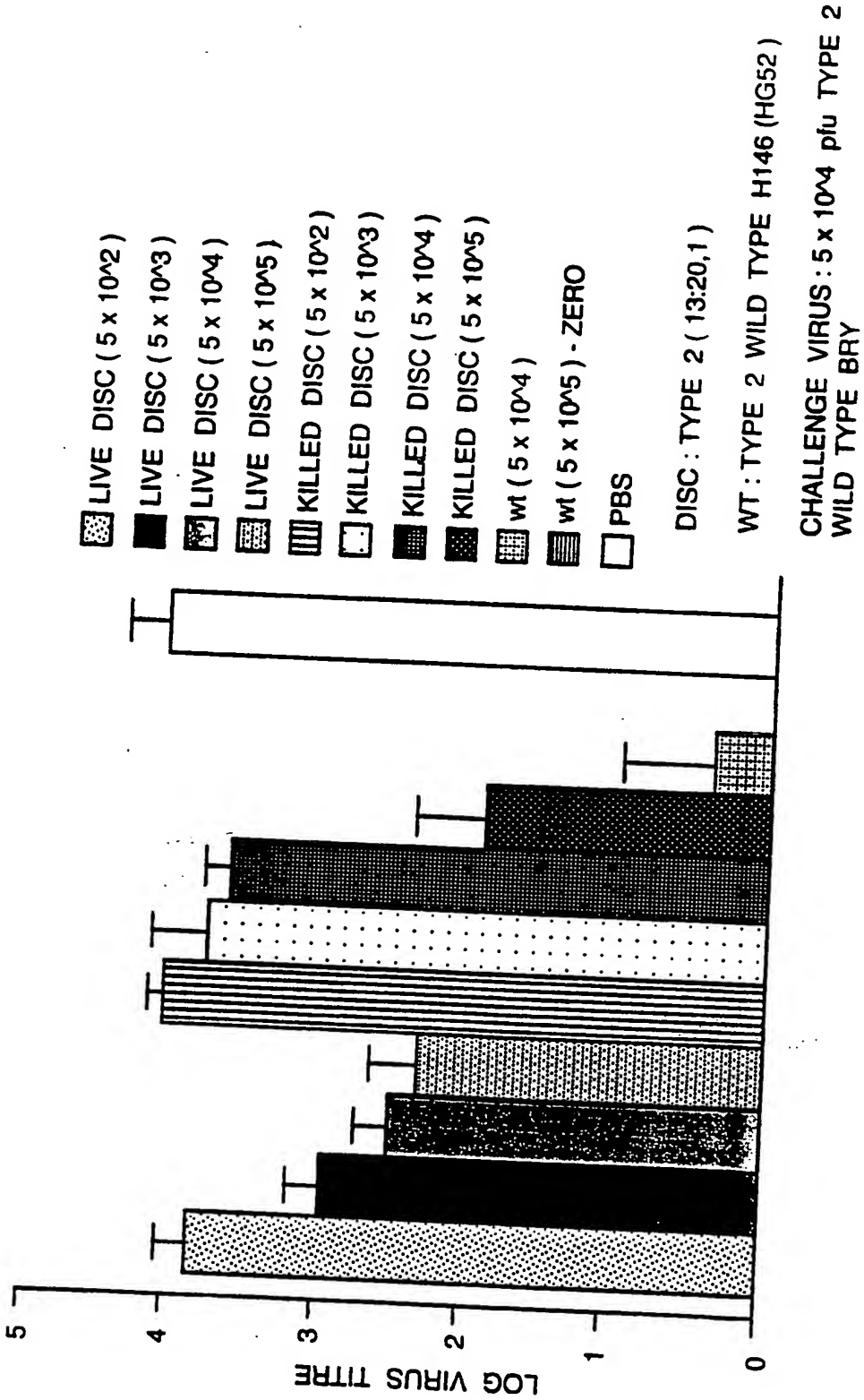

LIVE DISC (5 x 10^2)
LIVE DISC (5 x 10^3)
LIVE DISC (5 x 10^4)
LIVE DISC (5 x 10^5)
KILLED DISC (5 x 10^2)
KILLED DISC (5 x 10^3)
KILLED DISC (5 x 10^4)
KILLED DISC (5 x 10^5)
wt (5 x 10^4)
wt (5 x 10^5) - ZERO
PBS
DISC : TYPE 2 (13:20,1)
WT : TYPE 2 WILD TYPE H146 (HG52)
CHALLENGE VIRUS : 5 x 10^4 pfu TYPE 2 WILD TYPE BRY
LOG VIRUS TITRE
0
1
2
3
4
5

Fig.17.

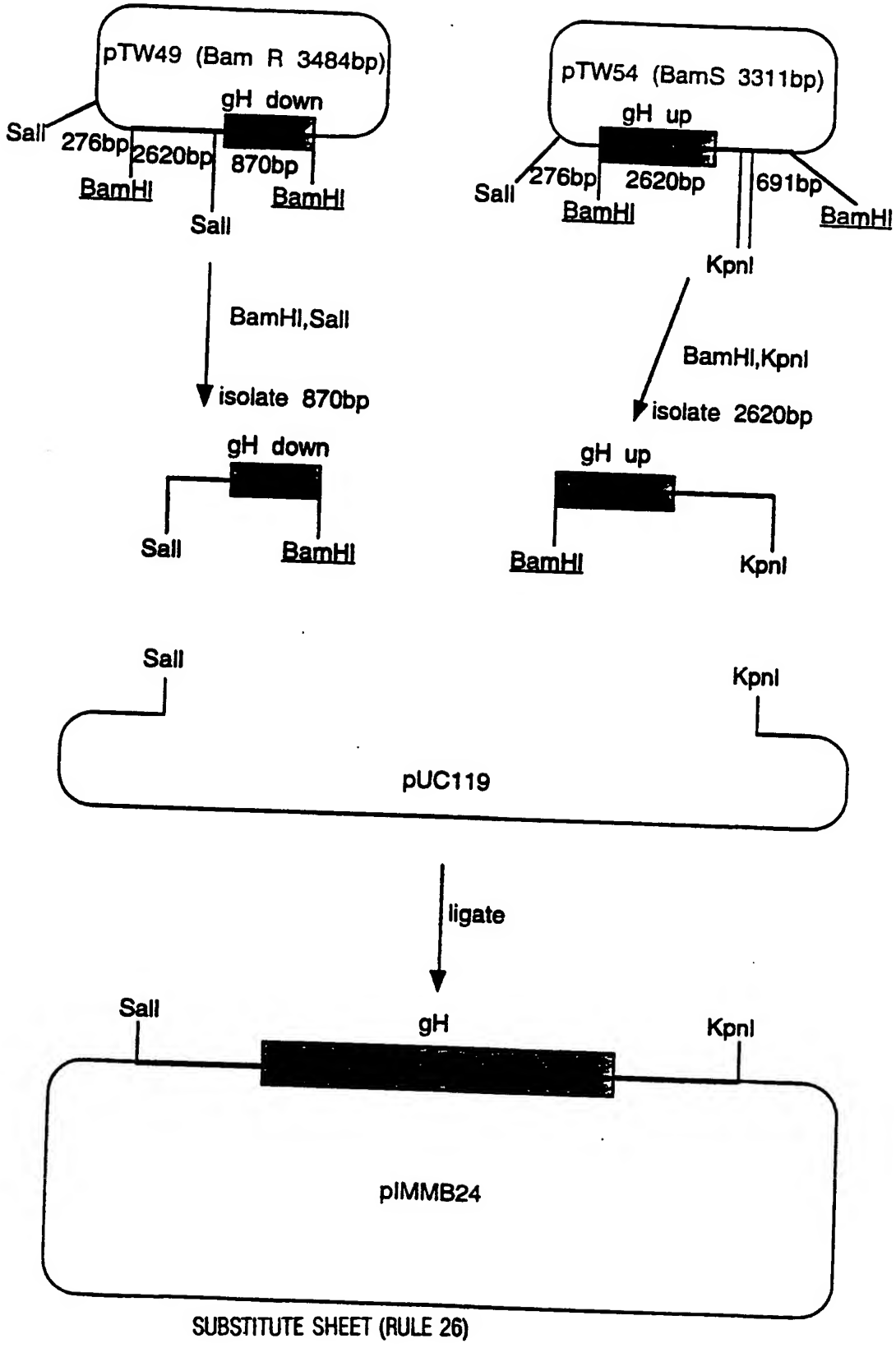

pTW49 (Bam R 3484bp)
gH down
SalI
276bp
2620bp
870bp
BamHI
BamHI
SalI
pTW54 (BamS 3311bp)
gH up
SalI
276bp
2620bp
691bp
BamHI
BamHI
KpnI
BamHI,SalI
isolate 870bp
gH down
SalI
BamHI
BamHI,KpnI
isolate 2620bp
gH up
BamHI
KpnI
SalI
KpnI
pUC119
ligate
SalI
gH
KpnI
pIMMB24

Fig.18

```
CTGCAGCGCGGCGGGAGGTGGCGGGAGGACTGGGGCCGGCTGACGGGGGTCGCCGCGGCG                60

ACCCCGCGCCCCGACCCCGAGGACGGCGCGGGGTCTCTGCCCCGCATCGAGGACACGCTG               120

TTTGCCCTGTTCCGCGTTCCCGAGCTGCTGGCCCCCAACGGGGACTTGTACCACATTTTT               180

GCCTGGGTCTTGGACGTCTTGGCCGACCGCCTCCTTCCGATGCATCTATTTGTCCTGGAT               240

TACGATCAGTCGCCCGTCGGGTGTCGAGACGCCCTGTTGCGCCTCACCGCCGGGATGATC               300

CCAACCCGCGTCACAACCGCCGGGTCCATCGCCGAGATACGCGACCTGGCGCGCACGTTT               360

GCCCGCGAGGTGGGGGGAGTTTAGTTCAAACACGGAAGCCCGAACGGAAGGCCTCCCGGC               420

GATGACGGCAATAAAAGAACAGAATAAAAGGCATTGTTGTCGTGTGGTGTGTCCATAAGC               480

GCGGGGGTTCGGGGCCAGGGCTGGCACCGTATCAGCACCCCACCGAAAAACGGAGCGGGC               540

CGATCCGTCCTTGTTTTCGGTCTGGTACTCCCTTTGTGCTTTTACCCTCACCCCACCCCA               600

TCCTTTGGCCCGCGCTTACGGCAACAAAGGGCCTCCGATAGCCTCCGAGGTGCGGACGCT               660

CTTTGGGCCGTGGGTACGGACACCCCCCCCATCTGCGGACTGGCAGCCGGGACGACGACCA               720
                                                          M
TGGGCCCCGGTCTGTGGGTGGTGATGGGGGTCCTGGTGGNCGTTGCCGGGGGCCATGACA               780
  G  P  G  L  W  V  V  M  G  V  L  V  V  V  A  G  G  H  D  T
CGTACTGGACGGAGCAAATCGACCCGTGGTTTTTGCACGGTCTGGGGTTGGCCCGCACGT               840
  Y  W  T  E  Q  I  D  P  W  F  L  H  G  L  G  L  A  R  T  Y
ACTGGCGCGACACAAACACCGGGCGTCTGTGGTTGCCCAACACCCCCGACGACCAGCGAC               900
  W  R  D  T  N  T  G  R  L  W  L  P  N  T  P  D  D  Q  R  P
CCCCAGCGCGGACGCTTGGCGCCCCCGGGCAACTCAACCTGACTACGGCATCCGTGCCCA               960
  P  A  R  T  L  G  A  P  G  Q  L  N  L  T  T  A  S  V  P  M
TGCTTCGGTGGTACGCCGAGCGCTTTTGTTTCGTGTTGGTCACCACGGCCGAGTTTCCTC              1020
  L  R  W  Y  A  E  R  F  C  F  V  L  V  T  T  A  E  F  P  R
GGGACCCCGGGCAGCTGCTTTACATCCCAAAGACCTATCTGCTCGGCCGGCCTCGGAACG              1080
  D  P  G  Q  L  L  Y  I  P  K  T  Y  L  L  G  R  P  R  N  A
CGAGCCTGCCCGAGCTCCCCGAGGCGGGGCCCACGTCCCGTCCCCCCGCCGAGGTGACCC              1140
  S  L  P  E  L  P  E  A  G  P  T  S  R  P  P  A  E  V  T  Q
```

Fig.18(Cont 1)

```
AGCTCAAGGGACTGCTGCACAACCCCGGCGCCTCCGCGATGTTGCGGTCCCGGGCCTGGG      1200
  L K G L L H N P G A S A M L R S R A W V

TAACATTCGCGGCCGCGCCGGACCGCGAGGGGCTTACGTTNCCGCGGGGAGACGACGGGG      1260
  T F A A A P D R E G L T T P R G D D G A

CGACCGAGAGGCACCCGGACGGCCGACGCAACGCGNCCCCGGGGCCGCCCGCGGGGGCGC      1320
  T E R H P D G R R N A A P G P P A G A P

CGAGGCATCCGACGACGAACCTGAGCATCGCGCATCTGCACAACGCGTCCGTGANCCTGC      1380
  R H P T T N L S I A H L H N A S V V L L

TGGCCGCCAGGGGCCTGCTACGGACTCCGGGTCGGTACGTGTACCTCTCCCCGTCGGCCT      1440
  A A R G L L R T P G R Y V Y L S P S A S

CGACGTGGCCCGTGGGCGTCTGGACGACGGGCGGGCTGGCGTTCGGGTGCGACGCCGCGC      1500
  T W P V G V W T T G G L A F G C D A A L

TCGTGCGCGCGCGATACGGGAAGGGCTTCATGGGGCTCGTGATATCGATGCGGGACAGCC      1560
  V R A R Y G K G F M G L V I S M R D S P

CTCCGGCCGAGATCATAGTGGTGCCTGCGGACAAGACCCTCGCTCGGGTCGGAAATCCGA      1620
  P A E I I V V P A D K T L A R V G N P T

CCGACGAAAACGCCCCGCGTGCTCCCCGCGCTCCGGCCGGCCCCAGGTATCGCGTCTTTG      1680
  D E N A P R A P R A P A G P R Y R V F V

TCCTGGGGGCCCCGACGCCCGCCGACAACGGCNTCGGCGCTGGACCCCCTCGGCGGGTGG      1740
  L G A P T P A D N G G G A G P P R R V A

CCGGCTACCCCGAGGAGAGCACGAACTACGCCCAGTATATGTCGCGGGCCTATGCGGAGT      1800
  G Y P E E S T N Y A Q Y M S R A Y A E F

TTTTGGGGGAGGACCCGGGCTCCGGCACGGACGACGCGCGTCCGTCCCTGTTCTGGCGCC      1860
  L G E D P G S G T D D A R P S L F W R L

TCGCGGGGCTGCTCGCCTCGTCGGGGTTTGCGTTCGTCAACGCGGCCCACGCCCACGACG      1920
  A G L L A S S G F A F V N A A H A H D A

CGATTCGCCTCTCCGACCTGCTGGGTTTTTTGGCCCACTCGCGCGTGCTGGCCGGCCTGG      1980
  I R L S D L L G F L A H S R V L A G L A

CCGCCCGGGGAGCAGCGGGCTGCGCGGCCGACTCGGTGTTCCTGAACGTGTCCGTGTTGG      2040
  A R G A A G C A A D S V F L N V S V L D

ACCCGGCGGCCCGTCTGCGGCTGGAGGCGCGCCTCGGGCATCTGGTGGCCGCGATCCTCG      2100
  P A A R L R L E A R L G H L V A A I L E

AGCGAGAGCAGAGCCTGGCGGCGCACGCGCTGGGCTATCAGCTGGCGTTCGTGTTGGACA      2160
  R E Q S L A A H A L G Y Q L A F V L D S

GCCCCGCGGCCTATGGCGGGTTGGCCCCGAGCGCGGCCCGCCTGATCGACGCCCTTGTTA      2220
  P A A Y G G L A P S A A R L I D A L V T

CCGCGCAGTTTCTCGGCGGCCGCGTAACCGCCCCGATGGTCCGCCGAGCGCTGTTTTACG      2280
  A Q F L G G R V T A P M V R R A L F Y A

CCACGGCCGTCCTCCGGGCGCCGTTCCTGGCGGGCGTGCCCTCGGCCGGGCAGCGGGAAC      2340
  T A V L R A P F L A G V P S A G Q R E R
```

Fig.18(Cont 2)

```
GCCCGCGGGGCCTCCTCATAACCACGGCCCTGTGTACGTCCGACGTCGCCGCGGCGACCC
  P  R  G  L  L  I  T  T  A  L  C  T  S  D  V  A  A  A  T  H                2400

ACGCCGATCTCCGGGCCGCGCTACGCAGGACCGACCACCAGAAAAACCTCTTCTGGCTCC
  A  D  L  R  A  A  L  R  R  T  D  H  Q  K  N  L  F  W  L  P                2460

CGGACCACTTTTCCCCATGCGCACGTTCCCTGCCGTTCGATCTCGCCGAGGGCGGGTTCA
  D  H  F  S  P  C  A  R  S  L  P  F  D  L  A  E  G  G  F  I                2520

TCCTGGACGCGCTGGCCATGGCCACCCGATCCGACATCCCGGCGGACGTCATGGCACAAC
  L  D  A  L  A  M  A  T  R  S  D  I  P  A  D  V  M  A  Q  Q                2580

AGACCCGCGGCGTGGCCTCCGCTCTCACGCNCTGGGCGACTCACAACGCCCTGATCCGCG
  T  R  G  V  A  S  A  L  T  T  W  A  T  H  N  A  L  I  R  A                2640

CCTTCGTCCCGGAGGCCACCCACCAGTGTAGCGGCCCGTCGCACAACGNGGAGCCCCGGA
  F  V  P  E  A  T  H  Q  C  S  G  P  S  H  N  N  E  P  R  I                2700

TCCTCGTGCCCATCACCCACAACGCCAGCTACGTCGTCACCCACTACCCCCCTTGCCCCC
  L  V  P  I  T  H  N  A  S  Y  V  V  T  H  Y  P  P  C  P  R                2760

GCGGGATCGGATACAAGCTTACGGGCGTTGACGTCCGCCGCCCGCTGTTTATCACCTATC
  G  I  G  Y  K  L  T  G  V  D  V  R  R  P  L  F  I  T  Y  L                2820

TCACCGCCACCTGCGAAGGGCACGCGCGGGAGATTGAGCCGCCGCGGCTGGTGCGCACCG
  T  A  T  C  E  G  H  A  R  E  I  E  P  P  R  L  V  R  T  E                2880

AAAACCGGCGCGACCTCGGCCTCGTGGGGGCCGTGTTTCTGCGCTACACCCCGGCCGGGG
  N  R  R  D  L  G  L  V  G  A  V  F  L  R  Y  T  P  A  G  E                2940

AGGTCATGTCGGTGCTGCTGGTGGACACGGATGCCACCCAACAGCAGCTGGCCCAGGGGC
  V  M  S  V  L  L  V  D  T  D  A  T  Q  Q  Q  L  A  Q  G  P                3000

CGGTGGCGGGCACCCCGAACGTGTTTTCCAGCGACGTGCCGTCCGTGGCCCTGTTGTTGT
  V  A  G  T  P  N  V  F  S  S  D  V  P  S  V  A  L  L  L  F                3060

TCCCCAACGGAACTGTGATTCATCTGCTGGCCTTTGACACGCTGCCCATCGCCACCATCG
  P  N  G  T  V  I  H  L  L  A  F  D  T  L  P  I  A  T  I  A                3120

CCCCCGGGTTTCTGGCCGCGTCCGCGCTGGGGGTCGTTATGATTACCGCGGCCCTGGCGG
  P  G  F  L  A  A  S  A  L  G  V  V  M  I  T  A  A  L  A  G                3180

GCATCCTCAGGGTGGTCCGAACGTGCGTCCCATTTTTGTGGAGACGCGAATAAACGGGTG
  I  L  R  V  V  R  T  C  V  P  F  L  W  R  R  E  *                        3240

TGTGGACGCAGCGGCGTCCAGCCCAACCCAACCGACTCCCTCCGTGTCCGCGGTCTGTTT                3300

GTTATTGTGTCCGCCGTGGCTCCGCTACCGCCTCTGTTCCTTTCCCTTCTCCATTCCTGT                3360

TTCCTTTCCTTCCCCCCCCCCCATAGTCCCCCGTATAGGCATACAACGGCATCCGTGGGT                3420

                    End of HSV2 UL21
TAGAAAACGACTGCACTTTATTGGGATATCTCACACAGACTGGCCGTGCTGGGCGCGAGC
                      *  V  S  Q  G  H                                        3480

CAGGCAAACGGTAAGCAGCGCGTCCAGGTACCCGGCGGTTCGCGTGCGGCCAGCCGCCCC                3540
```

Fig.18(Cont 3)

CGCCGGCCCGCGGTCAAACGCGGACATCCGGTCGACGTCCCCCACGGTCAGGACCAGGGA 3600

CGTCACGCCCGTCAGGCGCNCGGTATGCGTGGCCGCGGCCAGGCGTCCGTGGCCGGCGTA 3660

CAACACGCCCAGGAACGCGCCGAGGTACATGACGTGCTCGGGCGAGACGGACCCCCCCGG 3720

GGTCAGGCGTTGCGAGTCCACAAAGCGCAGCAGGGCGGCGCTGTCGGCCCGCGACGTCGC 3780

TCCCCACCGGCACGTCCTTGGGCGGGAGGAGGTCGAACATGAGGAGCTGCTCGCGA 3840

Fig.19.

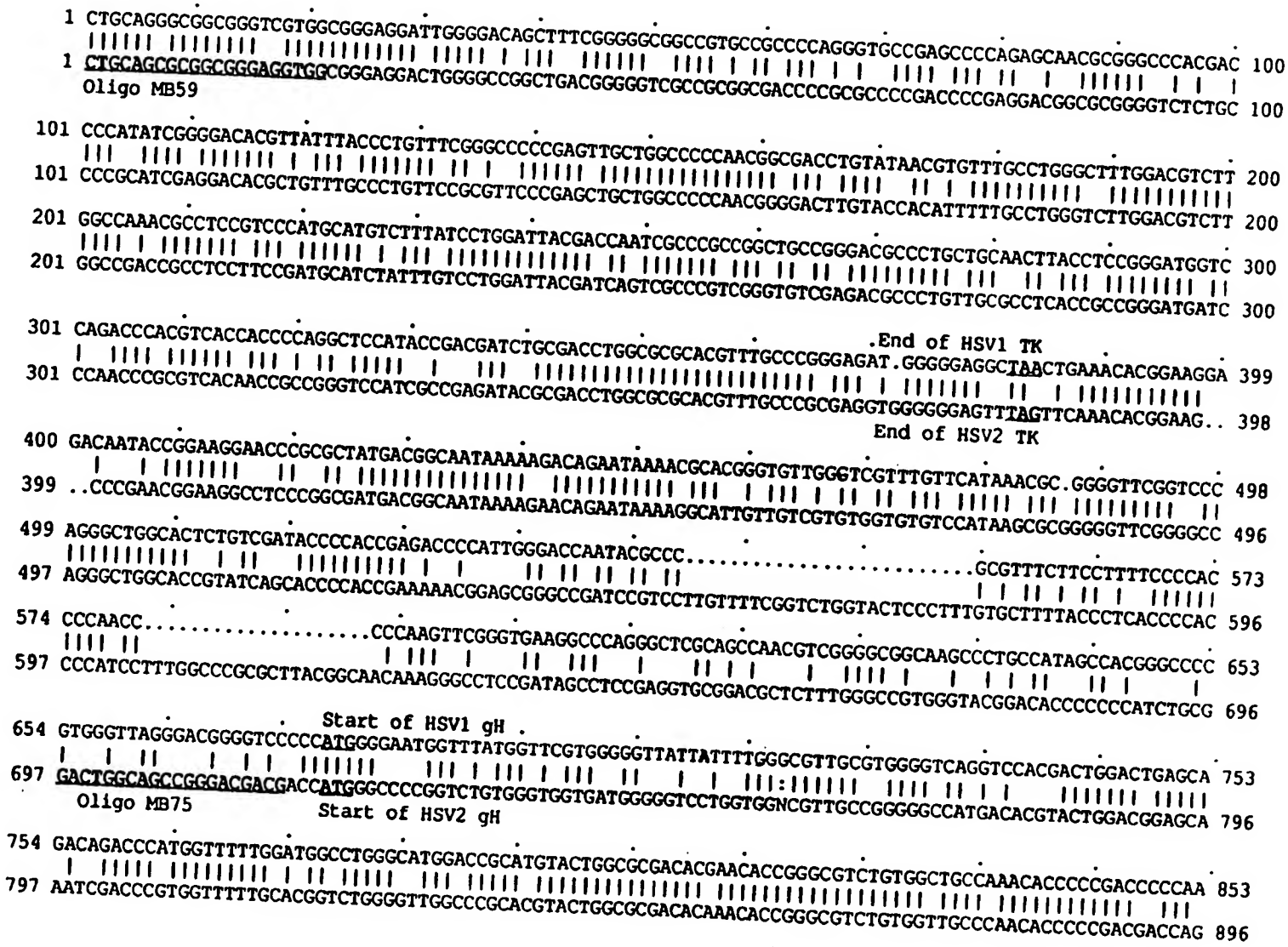

Oligo MB59
End of HSV1 TK
End of HSV2 TK
Start of HSV1 gH
Oligo MB75
Start of HSV2 gH

Fig.19. (Cont 1).

```
854  AAACCACC.GCGCGGATTTCTGGCGCCGCCGGACGAACTAAACCTGACTACGGCATCTCTGCCCCTTCTTCGCTGGTACGAGGAGCGCTTTTGTTTTGTA 952
897  CGACCCCCAGCGCGGACGCTTGGCGCCCCCGGGC.AACTCAACCTGACTACGGCATCCGTGCCCATGCTTCGGTGGTACGCCGAGCGCTTTTGTTTCGTG 995

953  TTGGTCACCACGGCCGAGTTTCCGCGGGACCCCGGCCAGCTGCTTTACATCCCGAAGACCTACCTGCTCGGCCGGCCCCCGAACGCGAGCCTGCCCGCCC 1052
996  TTGGTCACCACGGCCGAGTTTCCTCGGGACCCCGGGCAGCTGCTTTACATCCCAAAGACCTATCTGCTCGGCCGGCCTCGGAACGCGAGCCTGCCCGAGC 1095

1053 CCACCACGGTCGAGCCGACCGCCCAGCCTCCCCCCTCGGTCGCCCCCCTTAAGGGTCTCTTGCACAATCCAGCCGCCTCCGTGTTGCTGCGTTCCCGGGC 1152
1096 TCCCCGAGGCGGGGCCCACGTCCCGTCCCCCCGCCGAGGTGACCCAGCTCAAGGGACTGCTGCACAACCCCGGCGCCTCCGCGATGTTGCGGTCCCGGGC 1195

1153 CTGGGTAACGTTTTCGGCCGTCCCTGACCCCGAGGCCCTGACGTTCCCGCGGGGAGACAACGTGGCGACGGCGAGCCACCCGAGCGGGCCGCGTGATACA 1252
1196 CTGGGTAACATTCGCGGCCGCGCCGGACCGCGAGGGGCTTACGTTNCCGCGGGGAGACGACGGGGCGACCGAGAGGCACCCGGACGGCCGACG...CAAC 1292

1253 CCGCCCCCCCGACCGCCGGTTGGGGCCCGGCGGCACCCGACGACGGAGCTGGACATCACGCACCTGCACAACGCGTCCACGACCTGGTTGGCCACCCGGG 1352
1293 GCGNCCCCGGGGCCGCCCGCGGGGGCGCCGAGGCATCCGACGACGAACCTGAGCATCGCGCATCTGCACAACGCGTCCGTGANCCTGCTGGCCGCCAGGG 1392

1353 GCCTGTTGAGATCCCCAGGTAGGTACGTGTATTTCTCCCCGTCGGCCTCGACGTGGCCCGTGGGCATCTGGACGACGGGGGAGCTGGTGCTCGGGTGCGA 1452
1393 GCCTGCTACGGACTCCGGGTCGGTACGTGTACCTCTCCCCGTCGGCCTCGACGTGGCCCGTGGGCGTCTGGACGACGGGCGGGCTGGCGTTCGGGTGCGA 1492

1453 TGCCGCGCTGGTGCGCGCGCGCTACGGGCGGGAATTCATGGGGCTCGTGATATCCATGCACGACAGCCCTCCGGTGGAAGTGATGGTGGTCCCCGCGGGC 1552
1493 CGCCGCGCTCGTGCGCGCGCGATACGGGAAGGGCTTCATGGGGCTCGTGATATCGATGCGGGACAGCCCTCCGGCCGAGATCATAGTGGTGCCTGCGGAC 1592

1553 CAGACGCTAGATCGGGTCGGGGACCCCGCGGACGAAAACCCCCCGGGGGCTCTTCCCGGGCCCCCGGGCGGCCCCCGGTATCGGGTCTTTGTCCTAGGGT 1652
1593 AAGACCCTCGCTCGGGTCGGAAATCCGACCGACGAAAACGCCCCGCGTGC...TCCCCGCGCTCCGGCCGGCCCCAGGTATCGCGTCTTTGTCCTGGGGG 1689

1653 CCCTGACGCGGGCCGACAACGGCTCCGCGCTGGACGCCCTCCGCCGCGTGGGCGGCTACCCGGAGGAGGGCACGAACTACGCCCAGTTCCTGTCGCGGGC 1752
1690 CCCCGACGCCCGCCGACAACGGCNTCGGCGCTGGACCCCCTCGGCGGGTGGCCGGCTACCCCGAGGAGAGCACGAACTACGCCCAGTATATGTCGCGGGC 1789

1753 ATACGCGGAGTTTTTCTCGGGGGACGCGGGCGCCG...AGCAGGGCCCGCGCCCCCCTCTCTTCTGGCGCCTAACGGGGCTGCTCGCGACGTCGGGTTTT 1849
1790 CTATGCGGAGTTTTTGGGGGAGGACCCGGGCTCCGGCACGGACGACGCGCGTCCGTCCCTGTTCTGGCGCCTCGCGGGGCTGCTCGCCTCGTCGGGGTTT 1889
```

Fig.19. (Cont 2).

Fig.19.(Cont 3).

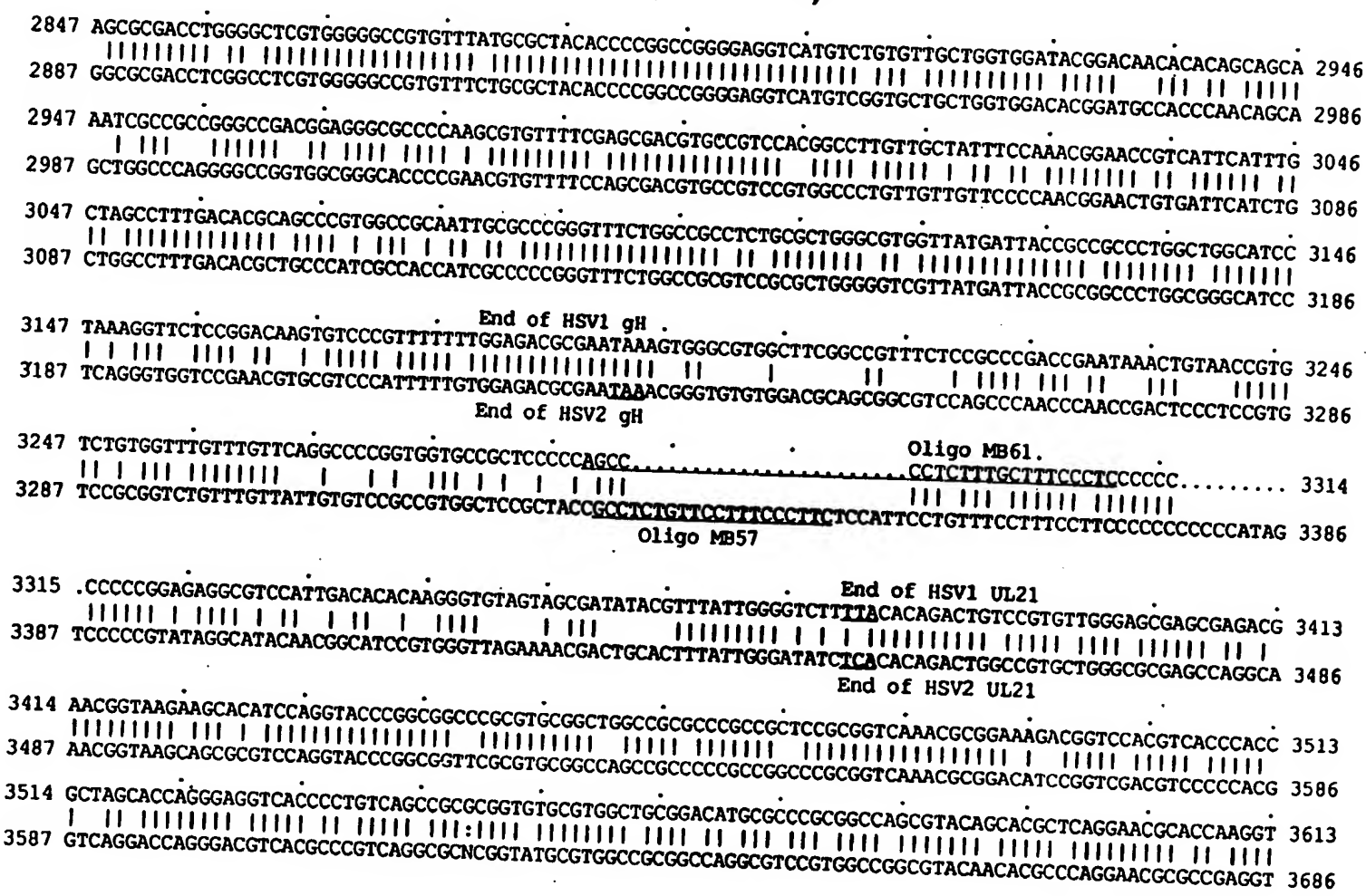

End of HSV1 gH
End of HSV2 gH
Oligo MB61.
Oligo MB57
End of HSV1 UL21
End of HSV2 UL21

Fig.19.(Cont 4).

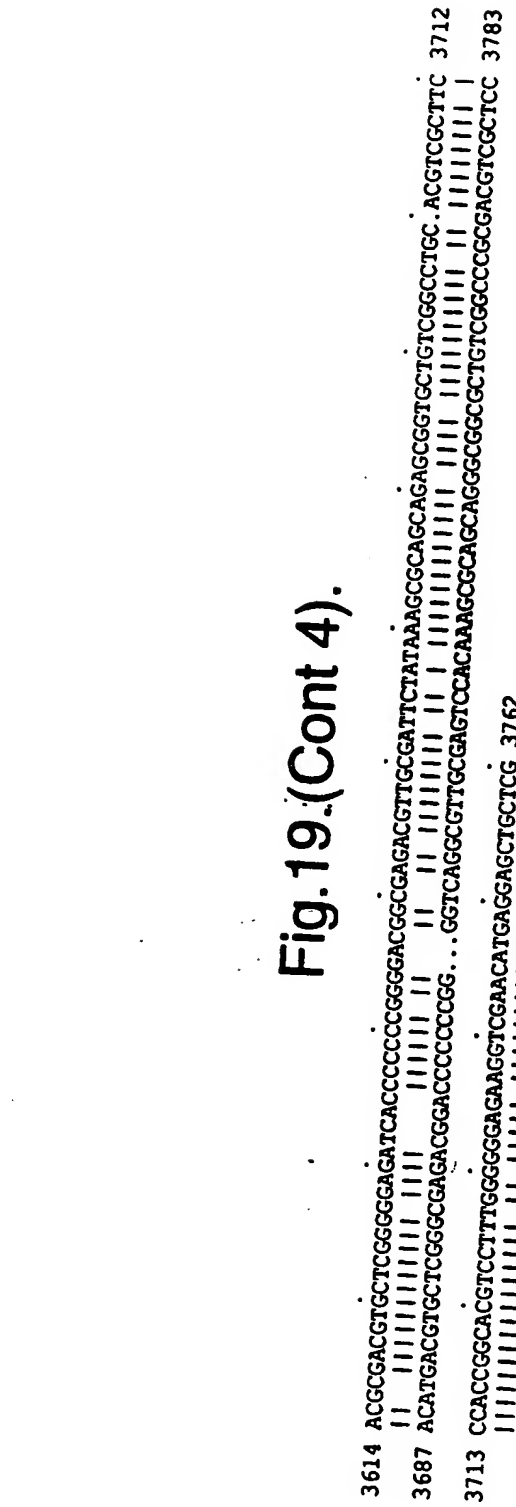

3614 ACGCGACGTGCTCGGGGGAGATCACCCCCCCGGGGACGGCGAGACGTTGCGATTCTATAAAGCGCAGCAGAGCGGTGCTGTCGGCCTGC.ACGTCGCTTC 3712
3687 ACATGACGTGCTCGGGCGAGACCGGACCCCCCCGG...GGTCAGGCGTTGCGAGTCCACAAAGCGCAGCGGCGGCGCTGTCGGCCCGCGACGTCGCTCC 3783
3713 CCACCGGCACGTCCTTTGGGGGGAGAAGGTCGAACATGAGGAGCTGCTCG 3762
3784 CCACCGGCACGTCCTTTGGGCGGGAGGGTCGAACATGAGGAGCCTGCTCG 3833
Oligo MB58

Fig.20.

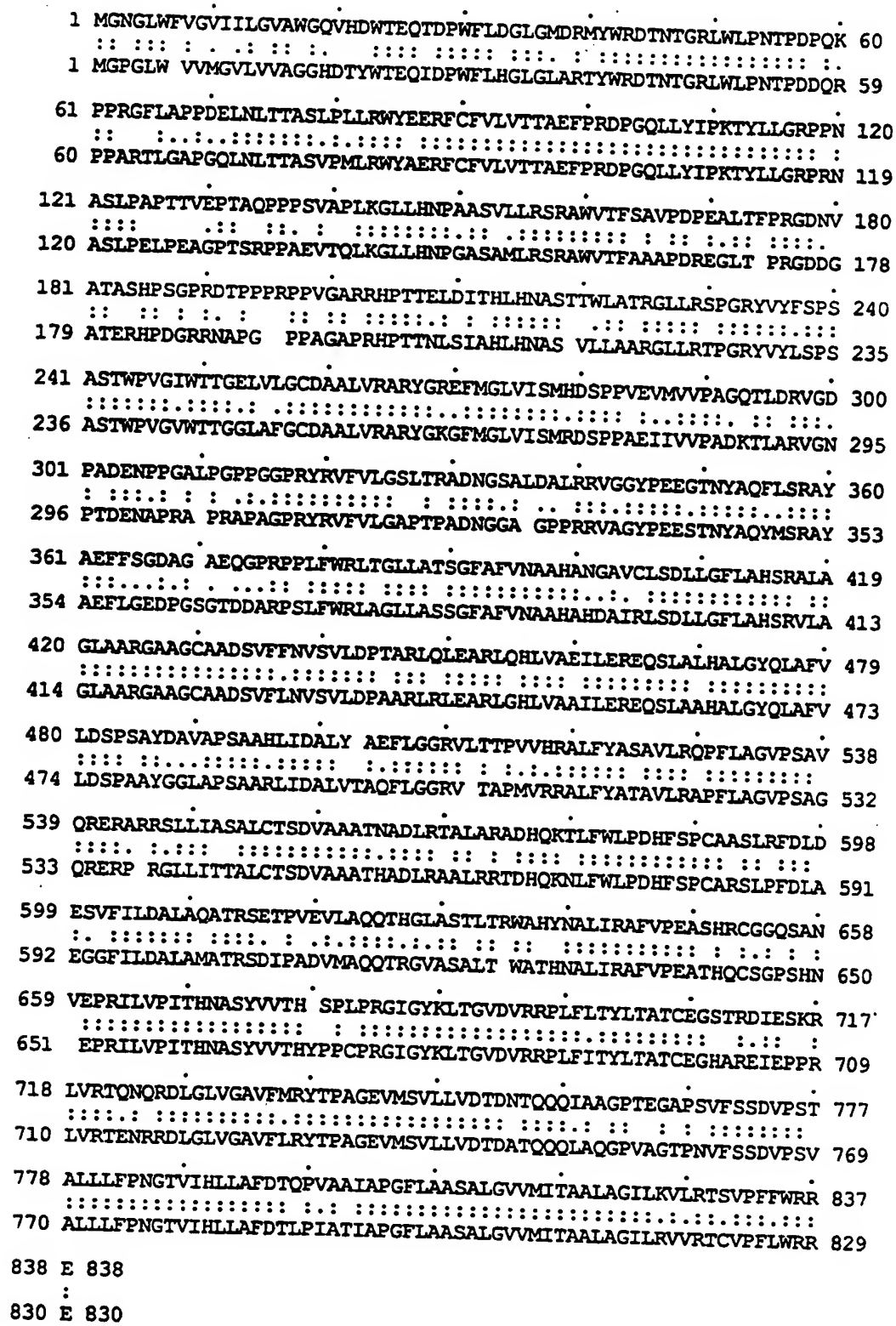

1 MGNGLWFVGVIILGVAWGQVHDWTEQTDPWFLDGLGMDRMYWRDTNTGRLWLPNTPDPQK 60
1 MGPGLW VVMGVLVVAGGHDTYWTEQIDPWFLHGLGLARTYWRDTNTGRLWLPNTPDDQR 59
61 PPRGFLAPPDELNLTTASLPLLRWYEERFCFVLVTTAEFPRDPGQLLYIPKTYLLGRPPN 120
60 PPARTLGAPGQLNLTTASVPMLRWYAERFCFVLVTTAEFPRDPGQLLYIPKTYLLGRPRN 119
121 ASLPAPTTVEPTAQPPPSVAPLKGLLHNPAASVLLRSRAWVTFSAVPDPEALTFPRGDNV 180
120 ASLPELPEAGPTSRPPAEVTQLKGLLHNPGASAMLRSRAWVTFAAAPDREGLT PRGDDG 178
181 ATASHPSGPRDTPPPRPPVGARRHPTTELDITHLHNASTTWLATRGLLRSPGRYVYFSPS 240
179 ATERHPDGRRNAPG PPAGAPRHPTTNLSIAHLHNAS VLLAARGLLRTPGRYVYLSPS 235
241 ASTWPVGIWTTGELVLGCDAALVRARYGREFMGLVISMHDSPPVEVMVVPAGQTLDRVGD 300
236 ASTWPVGVWTTGGLAFGCDAALVRARYGKGFMGLVISMRDSPPAEIIVVPADKTLARVGN 295
301 PADENPPGALPGPPGGPRYRVFVLGSLTRADNGSALDALRRVGGYPEEGTNYAQFLSRAY 360
296 PTDENAPRA PRAPAGPRYRVFVLGAPTPADNGGA GPPRRVAGYPEESTNYAQYMSRAY 353
361 AEFFSGDAG AEQGPRPPLFWRLTGLLATSGFAFVNAAHANGAVCLSDLLGFLAHSRALA 419
354 AEFLGEDPGSGTDDARPSLFWRLAGLLASSGFAFVNAAHAHDAIRLSDLLGFLAHSRVLA 413
420 GLAARGAAGCAADSVFFNVSVLDPTARLQLEARLQHLVAEILEREQSLALHALGYQLAFV 479
414 GLAARGAAGCAADSVFLNVSVLDPAARLRLEARLGHLVAAILEREQSLAAHALGYQLAFV 473
480 LDSPSAYDAVAPSAAHLIDALY AEFLGGRVLTTPVVHRALFYASAVLRQPFLAGVPSAV 538
474 LDSPAAYGGLAPSAARLIDALVTAQFLGGRV TAPMVRRALFYATAVLRAPFLAGVPSAG 532
539 QRERARRSLLIASALCTSDVAAATNADLRTALARADHQKTLFWLPDHFSPCAASLRFDLD 598
533 QRERP RGLLITTALCTSDVAAATHADLRAALRRTDHQKNLFWLPDHFSPCARSLPFDLA 591
599 ESVFILDALAQATRSETPVEVLAQQTHGLASTLTRWAHYNALIRAFVPEASHRCGGQSAN 658
592 EGGFILDALAMATRSDIPADVMAQQTRGVASALT WATHNALIRAFVPEATHQCSGPSHN 650
659 VEPRILVPITHNASYVVTH SPLPRGIGYKLTGVDVRRPLFLTYLTATCEGSTRDIESKR 717
651 EPRILVPITHNASYVVTHYPPCPRGIGYKLTGVDVRRPLFITYLTATCEGHAREIEPPR 709
718 LVRTQNQRDLGLVGAVFMRYTPAGEVMSVLLVDTDNTQQQIAAGPTEGAPSVFSSDVPST 777
710 LVRTENRRDLGLVGAVFLRYTPAGEVMSVLLVDTDATQQQLAQGPVAGTPNVFSSDVPSV 769
778 ALLLFPNGTVIHLLAFDTQPVAAIAPGFLAASALGVVMITAALAGILKVLRTSVPFFWRR 837
770 ALLLFPNGTVIHLLAFDTLPIATIAPGFLAASALGVVMITAALAGILRVVRTCVPFLWRR 829
838 E 838
830 E 830

Fig.21.

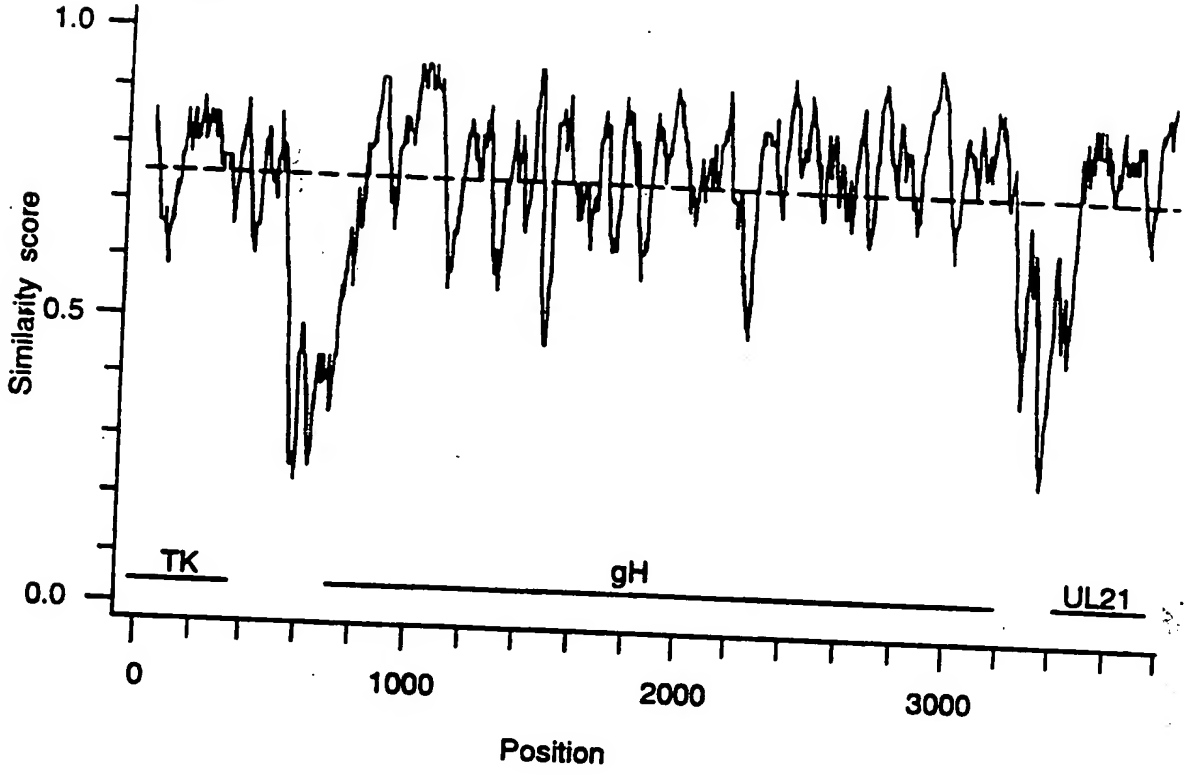

1.0
0.5
0.0
Similarity score
TK
gH
UL21
0
1000
2000
3000
Position

Fig.22.

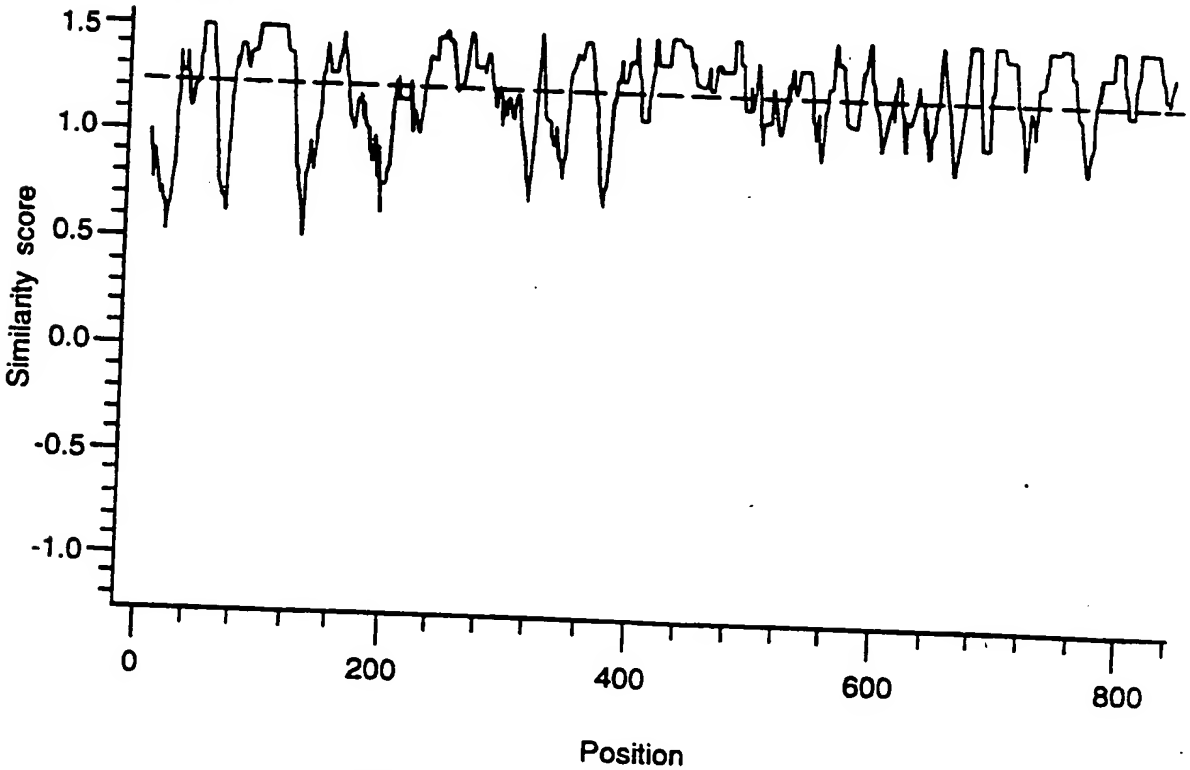

1.5
1.0
0.5
0.0
-0.5
-1.0
Similarity score
0
200
400
600
800
Position

Fig.23.

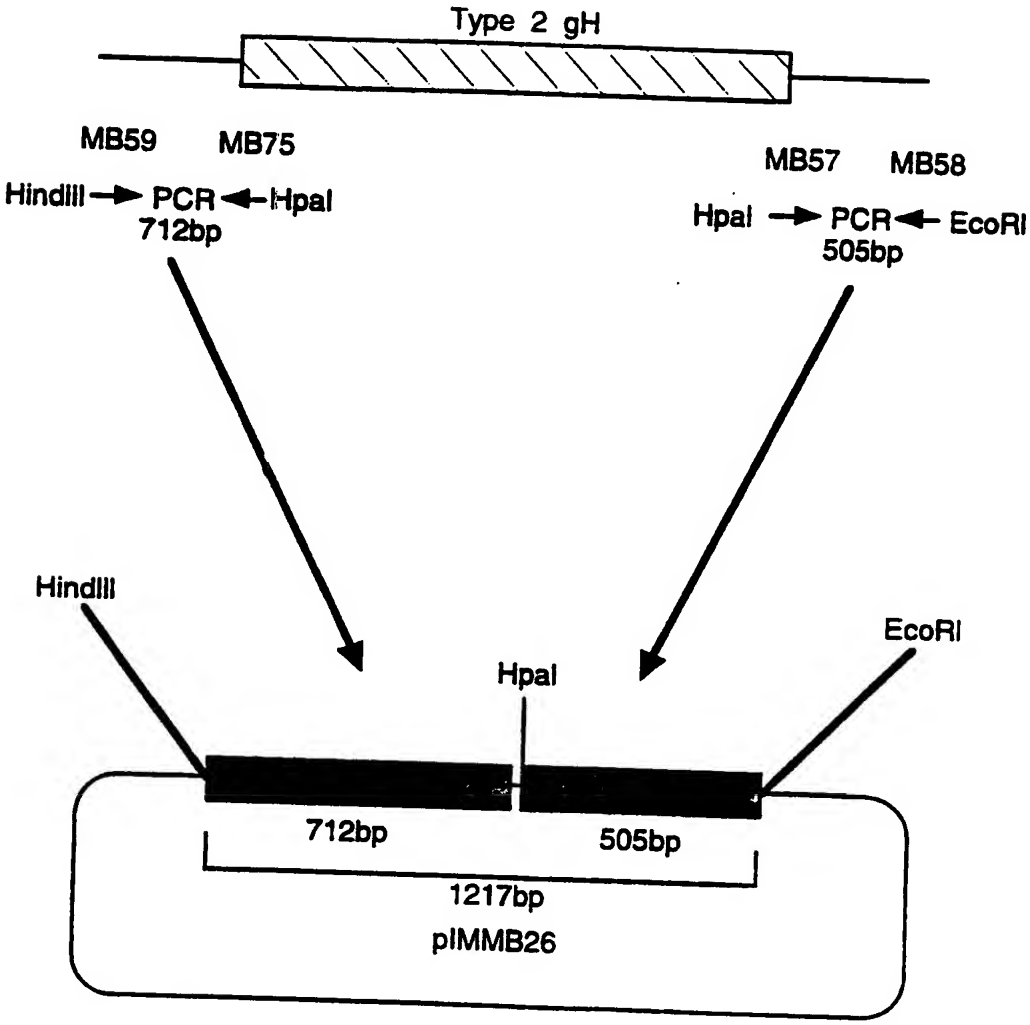

Type 2 gH
MB59
MB75
HindIII
PCR
HpaI
712bp
MB57
MB58
HpaI
PCR
EcoRI
505bp
HindIII
EcoRI
HpaI
712bp
505bp
1217bp
pIMMB26

Fig.24.

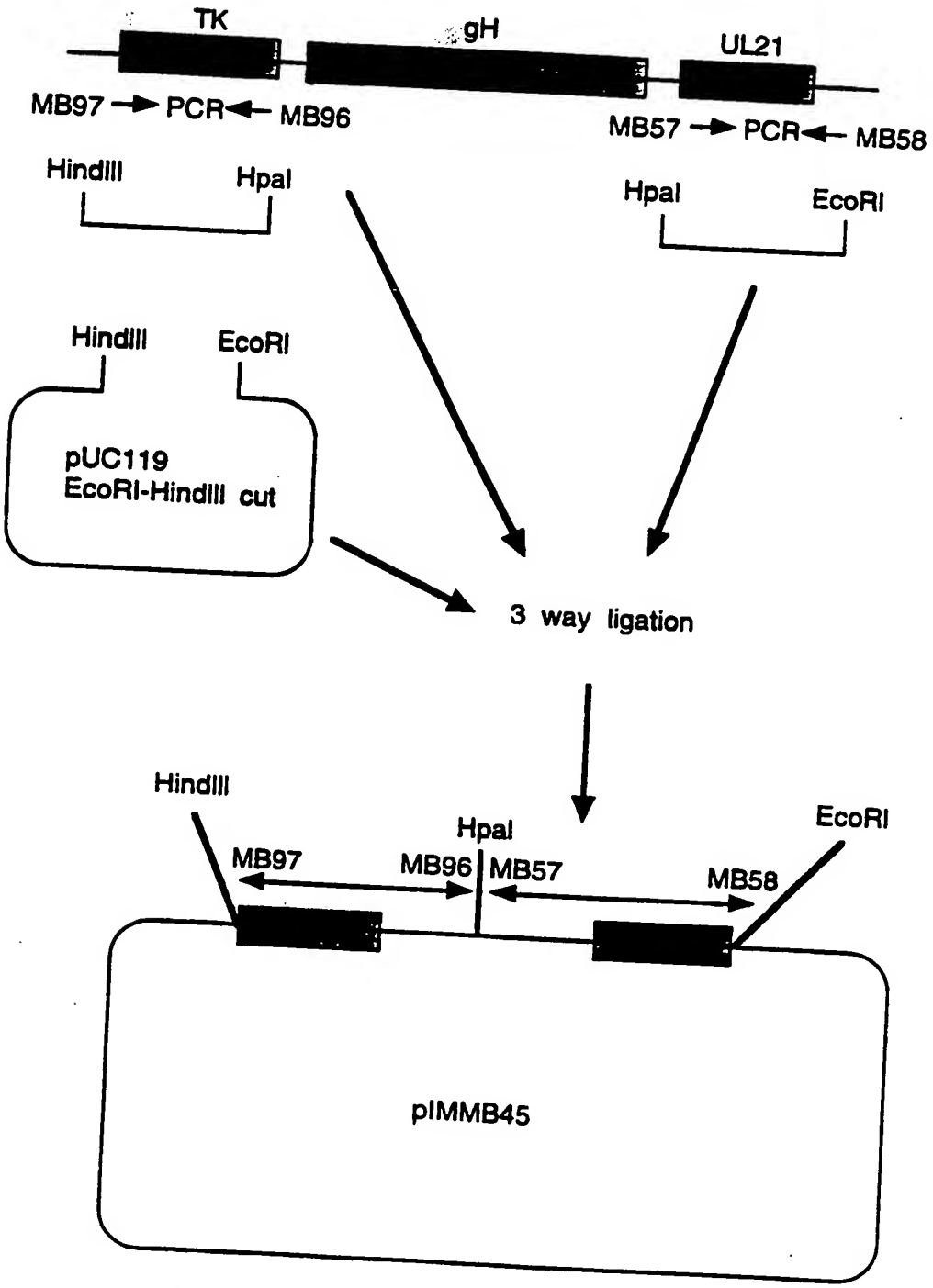

TK
gH
UL21
MB97
PCR
MB96
MB57
PCR
MB58
HindIII
HpaI
HpaI
EcoRI
HindIII
EcoRI
pUC119
EcoRI-HindIII cut
3 way ligation
HindIII
HpaI
EcoRI
MB97
MB96
MB57
MB58
pIMMB45

Fig.25.

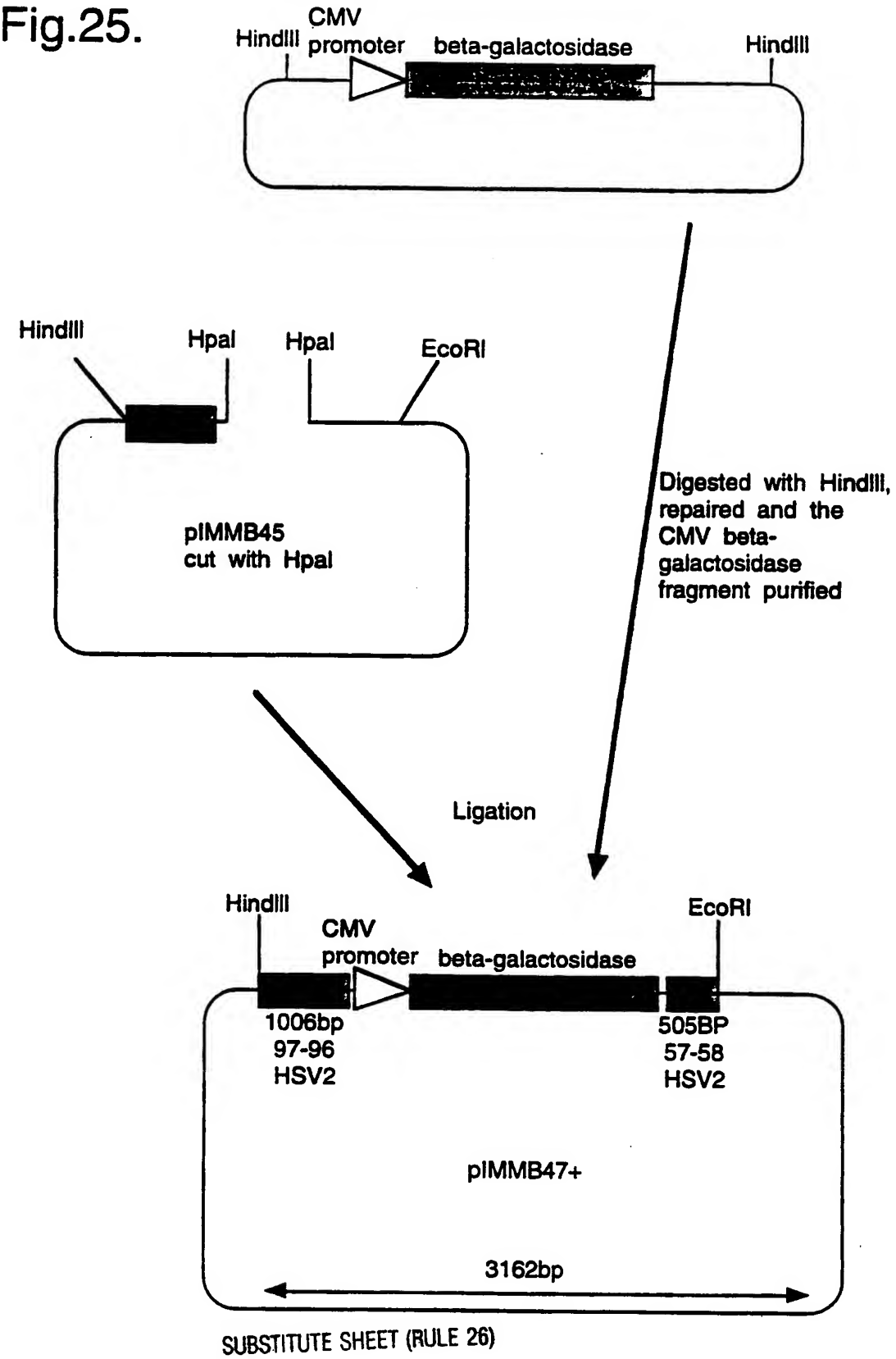
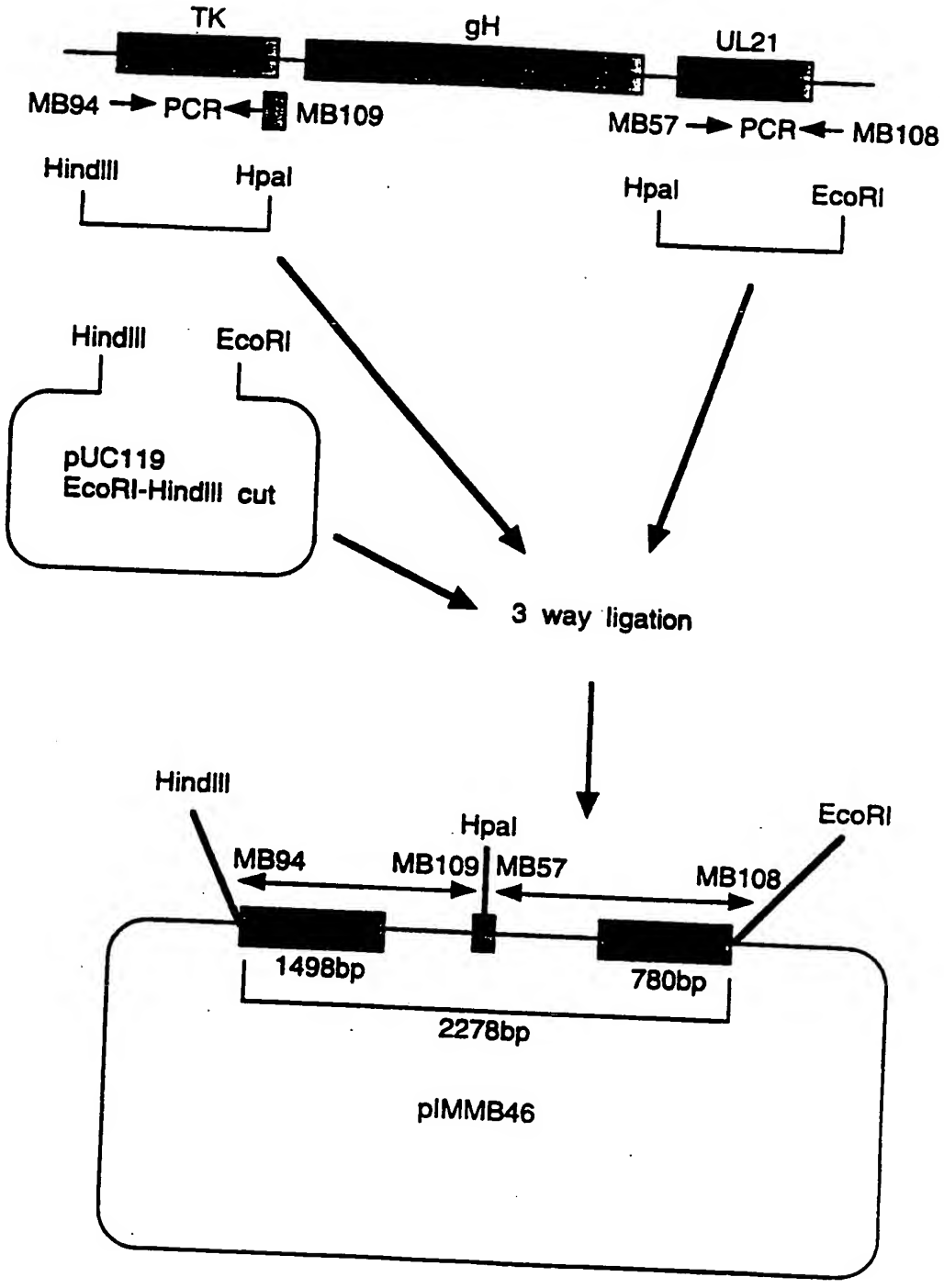

HindIII
CMV promoter
beta-galactosidase
HindIII
HindIII
HpaI
HpaI
EcoRI
pIMMB45
cut with HpaI
Digested with HindIII, repaired and the CMV beta-galactosidase fragment purified
Ligation
HindIII
CMV promoter
beta-galactosidase
EcoRI
1006bp
97-96
HSV2
505BP
57-58
HSV2
pIMMB47+
3162bp

Fig.26.


TK
gH
UL21
MB94
PCR
MB109
MB57
PCR
MB108
HindIII
HpaI
HpaI
EcoRI
HindIII
EcoRI
pUC119
EcoRI-HindIII cut
3 way ligation
HindIII
HpaI
EcoRI
MB94
MB109
MB57
MB108
1498bp
780bp
2278bp
pIMMB46

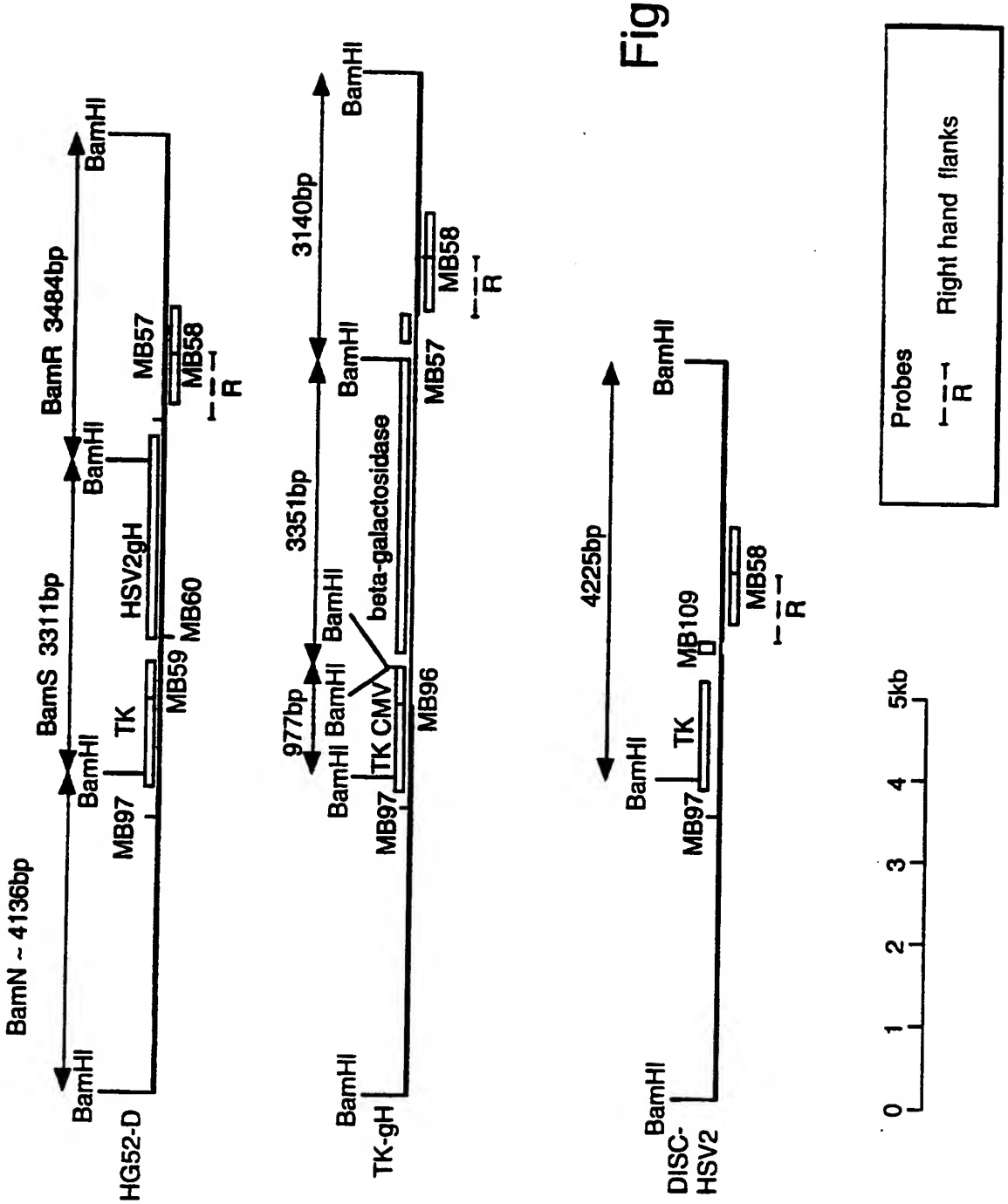
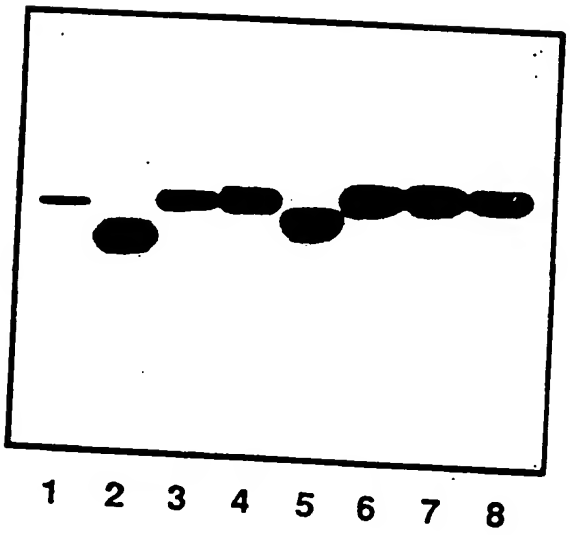

HG52-D
BamHI
BamN ~ 4136bp
BamS 3311bp
BamR 3484bp
BamHI
TK
HSV2gH
MB97
MB59
MB60
MB57
MB58
R
TK-gH
BamHI
977bp
3351bp
3140bp
TK CMV
beta-galactosidase
MB96
DISC-HSV2
4225bp
MB109
Probes
Right hand flanks
0
1
2
3
4
5kb

Fig.27.

Fig.28.



INTERNATIONAL SEARCH REPORT

Internatio... Application No
PCT/GB 94/00572

A. CLASSIFICATION OF SUBJECT MATTER
IPC 5 C12N15/86 C12N7/04 A61K39/245 C12N15/38

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 5 C12N C07K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JOURNAL OF CELLULAR BIOCHEMISTRY vol. SUPPL, no. 17D , 13 March 1993 page 84 MCLEAN, L. ET AL. 'Protection against HSV-2-induced disease by vaccination with a GH-deleted HSV-1 virus' see abstract N 422	1-4,6,7, 9,11-14, 17-19, 22-26, 29-33, 35,37
O,X	& Keystone symposium on molecular immunology of virus infections TAOS, USA, MARCH 17-24 1993	1-4,6,7, 9,11-14, 17-19, 22-26, 29-33, 35,37

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 July 1994	23. 08. 94
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+ 31-70) 340-2040, Tx. 31 651 epo nl, Fax (+ 31-70) 340-3016	**Authorized officer** Chambonnet, F

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Internatic... Application No
PCT/GB 94/00572

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO,A,92 05263 (IMMUNOLOGY LTD) 2 April 1992 cited in the application	1-4,6,7, 11-14, 16, 22-26, 28,30-34
Y	see the whole document	5,8-10, 15, 17-21, 27,29, 36,37
X,P	JOURNAL OF VIROLOGY vol. 68, no. 2 , February 1994 pages 927 - 932 FARRELL, H.E. ET AL. 'Vaccine potential of Herpes Simplex Virus type 1 mutant with an essential glycoprotein deleted'	1-4,6,7, 11-14, 16, 22-26, 30-34
P,Y	see the whole document	5,8-10, 15, 17-21, 27-29, 36,37
Y	FIELDS, B.N. & KNIPE, D.M. 'VIROLOGY' 1991 , RAVEN PRESS , NEW YORK, USA see page 1847 - page 1849	5,8-10, 15,28
P,X	WO,A,94 01573 (AKZO N.V.) 20 January 1994 see the whole document	1-4,6,8, 11,12, 22-24, 30-32
P,X	WO,A,94 03595 (AKZO N.V.) 17 February 1994 see the whole document	1-4,6,8, 11,12, 22-24, 30-33

1

INTERNATIONAL SEARCH REPORT

Inte. ional application No.
PCT/GB94/00572

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. [X] Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
Remark: Although claims 30-37 are directed to a method of treatment of the human/animal body the search has been carried out and based on the alleged effects of the compound/composition.

2. [ ] Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. [ ] Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. [ ] As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. [ ] As all searchable claims could be searches without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. [ ] As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. [ ] No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

[ ] The additional search fees were accompanied by the applicant's protest.

[ ] No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/GB 94/00572

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
WO-A-9205263	02-04-92	AU-A-	8648991	15-04-92
		CA-A-	2091678	26-03-92
		EP-A-	0550553	14-07-93
		GB-A,B	2263480	28-07-93
		JP-T-	6504194	19-05-94
WO-A-9401573	20-01-94	AU-B-	4589893	31-01-94
WO-A-9403595	17-02-94	AU-B-	4560693	03-03-94